Files are in Adobe, AVCHD Video (.m2ts), .avi format, MPEG-4 Movie (.mp4), and Windows Media Audio/Video file (.wmv) files. Download the newest version from Adobe.

2011 Joint Service Power Expo

Myrtle Beach, SC

2 – 5 May 2011

Agenda

TUESDAY, MAY 2, 2011

ADMINISTRATIVE & WELCOME REMARKS

- Marc Gietter, 2011 JSPE Conference Chair

GENERAL SESSION

KEYNOTE SPEAKER #2:

- Mr. Bill Heisey, Lockheed Martin

"Update on USMC Expeditionary Power and Energy Acquisition", Mike Gallagher, Program Manager, Marine Corps Systems Command

"Army Power Needs"

- MAJ Steve Meredith, USA

CONFERENCE BREAKOUT SESSIONS

SESSION 1

Battery Monitoring & Maintenance

- 12809 - "Battery Management System for Monitoring up to Six Lead Acid Batteries at the Individual Battery and System Levels", Dr. David Liu, Vice President Research and Development, HDM Systems Corporation
- L-3 - "Battery Maintenance", Mr. Mark Abelson, Director-Govt/Military Programs, Pulsetech Products Co.,

SESSION 2

Micro/Smart Grids 1

- 12093 - "Project Manager Mobile Electric Power Smart Grid Efforts", Miss Jennifer Whitmore, Electrical Engineer, CERDEC C2D Army Power
- 12788 - "Developing Hybrid and Sustainable Energy Solutions for the Increasing Power and Mobility Needs of the Warfighter", Mr. Dan Madden, PE, CEO/General Manager, Energy Technologies, Inc.

SESSION 3

Strategic Planning for Energy Initiative

- 12303 - “DOD-DOE partnering - Moving out on Transitioning Fuel Cells”, Mr. Peter Devlin, Market Transformation Team Lead, U.S. Department of Energy (EE-2H) and Mr. John Christensen
- 12835 - “High Energy Density Systems (HEDS) R&D Plan”, Mr. Kyle Werner, Division Manager for Code GXS, Naval Surface Warfare Center Crane Division and Ms. Susan Waggoner
- L-1- NSWC Crane, Energy Power & Interconnect Technology Division/ARPA, Mr. David Miller, Test and Evaluation Branch Manager, NSWC Crane Division

SESSION 4

Battery Charging

- 12127 - “Mobile Charging System”, Mr. Rick Silva, Senior Systems Engineer, CME
- 12076 – “Advancing Renewable Energy Technology Commercialization through Federal, State and Local Collaborations, Mr. Russ Keller, Vice President, ATI

SESSION 5

Micro/Smart Grids 2

- 12351 - “The Quest for the Holy Grid”, Mr. Ken Deylami, Lead General Engineer, CERDEC C2D Army Power
- 12795 - “A123’s Advanced Grid Storage: Distributed Generation and Microgrids for Increased Energy Efficiency & Security”, Ms. Kimberly Pargoff, Government Grid Director, A123 Systems
- 12808 - “Gen Set Eliminator - Optimizes Fuel Consumption”, Mr. Andrew Naukam, VP Technology, Energy Storage Systems, Ultralife Corporation and Dr. Ron Wang

SESSION 6

Getting Product to the User

- L-12 - Army Training and Doctrine Command “TRADOC”, COL Paul Roege, USA, FORSCOM
- 12838 - “Rapid Fielding, and the Army Safety Release/Safety Confirmation Process”, LTC Daniel Rusin, USA (Ret.), Test Manager, DTC, Army Test and Evaluation Command and LTC Richard Lonardo, USA (Ret.)

-

WEDSDAY, MAY 4, 2011

SESSION 7

Advanced Battery Systems

- 11769 - “Squad Power - Advanced Lithium Power Sources”, Mr. Jim Hess, Director, Defense Sales, Saft America, Inc. and Mr. Pat Lyman
- 11911 &11913 - “Universal Light Weight Smart Battery for THHR\Wireless Light Weight Smart Battery for Tactical Handheld radio”, Mr. Merdod Badie, Senior Project Manager, Thales Communications Inc.
- 12785 - “Large Format Lithium Power Cells for Demanding Hybrid Applications”, Mr. Adam Hunt, Manager of Government Programs, ENERDEL

SESSION 8

USMC Power Initiatives

- 12784 - “Small unit power requirements from the customers perspective” Lt Col Michael Bissonnette, USMC (Ret.), L-3 Communications
- 12081 - “Marine Corps Renewable Energy and Micro Gridding Programs” Mr. Clint Govar, Engineer, MCSC
- 12125 & 12126 - “Alternative Energy Based Expeditionary Power Solutions” Dr. Carl Kirkconnell, Iris Technology Corporation

SESSION 9

Generators

- 12078 - “High Power Density Turbine Based Generation Systems” Mr. Hernando Munevar, President & CEO, Candent Technologies, Inc.
- 12105 - “Man-Portable Tactical Power: Report on Efforts” Mr. S. Paul Dev, President, D-STAR Engineering Corp.
  - D-STAR generator AVCHD Video (.m2ts)
- L – 6 - “Development of a lightweight, man-portable, heavy-fuel generator” Mr. Les Gray, Executive in Residence, QinetiQ North America and Andrew A. Pouring, D.Eng. CEO and Chief Technical Officer Sonex Research, Inc.

SESSION 10

BA-XX90 Batteries

- 12102 - “Next Generation 5X90 Battery” Mr. Carlos Negrete, New Technologies Engineering Manager, SAFT America
- 12777 - “Recent Advances for Lithium Carbon mono-fluoride Batteries for Portable Applications” Dr. Gregg Bruce, Chief Scientist, EaglePicher Energy Products
- 12823 - “Li-CFx/MnO2 Hybrid D-cell with Wide Operating Temperature Range for Military Batteries”, Dr. Xinrong Wang, Research Manager, Ultralife Corporation and Mr. David Modeen

SESSION 11

Fuel Cells I

- 11909 - “OSD Fuel Cell Roadmapping Effort” Mr. Jim Gucinski
- 12071 - “Manhattan Fuel Cell Manufacturing Technology Study”, Ms. Rebecca Morris, Product and Applications Engineer, ACI Technologies, Inc. and Mr. Carmine Meola
- 12132 - “Renewable energy generation and storage for reduced logistics burden”, Ken Pearson, President & COO Jadoo Power

SESSION 12

Renewable Energy 1

- 12124 - “Merlin Adapters for Tactical Radios – The New Standard in Power Management”, Mr. Ed O'Rourke, Iris Technology Corporation
- 12111 - “Design Development and Testing of a Rapidly Deployable Man-Transportable Renewable Energy System”, Mr. Eric Shields, Mechanical Engineer, NSWCCD and Mr. Alex Askari
- 12180 - “REMM: Expeditionary Power”, Mr. Stephen Nimmer, Director, Engineering Defense Technology Development Oshkosh Corporation
    - NPC Generator video clip.avi

SESSION 13

Large Format Rechargeable Batteries

- 12131 - “Technical Challenges for Vehicle 12V/24V Lithium Ion Battery Replacement”, Mr. David Skalny, Energy Storage Deputy Team Leader, Ground Vehicle Power & Mobility Directorate, U.S. Army TARDEC
- 12812 - “Integration of NanoPhosphate Prismatic Battery Cells into the XM1124 Hybrid Electric HMMWV”, Dr. Mike Marcel, Government Operations Manager, A123 Systems
- 12187 &12188 - “Large Format Li Ion Replacement Packs/Light Weight, High Power and -40°C Capable Li-ion Battery”, Dr. Hisashi Tsukamoto, CEO, CTO, Quallion LLC and Mr. Vincent Visco

SESSION 14

Fuel Cells 2

- 12103 - “JP-8 Compatible Fuel Cell Gensets at Lockheed Martin”, Mr. Steven Sinsabaugh, Lockheed Martin Fellow, Lockheed Martin MS2
- 12771 - “Reducing Warfighter Load by Improving Energy Density”, Mr. Philip Hassell, Sales and Business Development Manager, SFC Energy, Inc.
- 12801 - “Solid Oxide Fuel Cells to reduce the logistic burden of resupplying the Warfighter through point of need power generation”, Mr. Jon Rice, Business Segment Leader, Ultra-AMI

SESSION 15

Renewable Energy 2

- 12147 - “Solar Photovoltaic Tactical Electric Power Systems”, Mr. Cao Chung, Chemical Engineer, U.S. Army CERDEC C2D
- 12096 - “Regenerative Solar Power Solutions for Extended Mission Endurance”, Mr. John Hart, Business Development, ABSL Power Solutions Inc.
- 12799 - “Utilization of a Ducted Wind Turbine in a Trailer-Mounted Renewable Energy Micro-grid”, Mr. Mark Matthews, VP of Sales and Marketing, WindTamer Corporation and Mr. Adeeb Saba
    - WindTamer MPEG-4 Movie (.mp4)

SESSION 16

On-Board Vehicle Power (OBVP) 1

- 12178 - “Oshkosh On-Board Vehicle Power Systems: Advancement from Heavy to Light Vehicles’, Mr. Nader Nasr, Senior, Chief Engineer, Adv Products Group, Oshkosh Corporation (Please contact presenter for presentation)
- 12834 - “Office of Naval Research Maneuver Science and Technology Programs in Fuel Efficiency and Battlefield Power”, Mr. Michael Mimnagh, Engineer, Naval Surface Warfare Center
- 12344 & 12345 - “Modeling and Simulation of an OBVP Enhanced Vehicle to Improve Fuel Economy\On-Board Vehicle Power: Past, Present and Future”, Mr. Gary Grider, Senior Project Manager, DRS Test and Energy Management

- 12149 – “Systems Approach to OBVP Requirements”, Dan Cowan, Kollmorgen, Business Development Manager

SESSION 17

Building Government Industry Relationships

- 12076 - “Advancing Renewable Energy Technology Commercialization through Federal, State and Local Collaborations”, Mr. Russ Keller, Vice President, Advanced Technology International
- 12302 - “Rapid Fielding, and the Army Safety Release/Safety Confirmation Process”, Mr. Glen Bowling, Vice President Sales, Saft Specialty Battery Group

SESSION 18

Renewable Energy 3

- 12829 - “Development of Flexible, Lightweight CIGS Photovoltaic Power Solutions for Today’s Military”, Mr. Ashu Misra, Senior Vice President Sales & Corporate Development, Ascent Solar Technologies and Mr. Brian Blackman, Director of Corporate Development
- 12160 - “Training Center Petaluma Solar Power”, CDR Jeff Good, USCG and CAPT Chris Hall and Mr. Tony vanWinden

SESSION 19

Micro/Smart Grids 3

- 12143 - “Fuel Consumption Model for Tactical Operations Centers (TOCs)”, Ms. Jennifer Barker, SURVICE Engineering Company
- 12270 - “A demonstration of intelligent control technology in tactical power grids”, Dr. Darrell Massie, Chief Technology Officer, Intelligent Power & Energy (Please contact presenter for presentation)

<u>THURSDAY, MAY 5, 2011</u>

SESSION 20

OBVP- 2

- L – 9 - “Advanced Power Systems for Enhanced Capability and Fuel Economy”, CAPT Lynn Petersen, USN, Deputy Director, PMS 320 (Electric Ships Office NAVSEA) ***“This presentation is Distribution A, Approved for Public Release”***
- 12448 - “Permanent Magnet Generators for On Board Vehicle Power”, Mr. James Burns, P.E., Director of Engineering, DRS Power Technology, Inc.
- 12346 & 12347 - “Integrating Power Plants Into Powertrains”, Mr. Brent Brzezinski, Ph.D., Engineering Specialist, DRS Test and Energy Management

SESSION 21

Energy for Garrisons

- L- ?? - “Using Fuel Cells for Building Power”, Ms. Ruth F. Cox, President and Executive Director, Fuel Cell and Hydrogen Energy Association

SESSION 22

Hybrid Systems

- 11848 & 11849 - “The Alternative Energy Coalition: A Struggle for Power in the Expeditionary Environment”, Mr. Thomas Lederle, Vice President Product Development, NEST Energy Service
  - Generator Windows Media Audio/Video file (.wmv)
  - Load Control Windows Media Audio/Video file (.wmv)
  - Raptor Windows Media Audio/Video file (.wmv)
- 12064 - “Optimizing Generator Efficiency with Energy Storage Technologies”, Mr. William Moorehead, Chief Operating Officer, Earl Energy, LLC
- 12066 - “Reducing Fuel Consumption with Hybrid Renewable/Conventional Micro-grids.”, COL Albert Zaccor, USA (Ret.) CEO, Solar Stik

SESSION 23

OBVP- 3

- 12836 - “Polaris REX Technology”, Mr. Stacy Stewart, Director, Powertrain Engineering Polaris Industries, Inc. and Mr. Patrick Weldon

SESSION 24

Power to Remote Locations

- 12813 - “Pulse Energy Management System – Real Time Optimization of Remote Deployment Energy Systems”, Mr. Bruce Cullen, Manager - Remote Communities, Pulse Energy
- 12825 - “SentryPOST Solution for Remote Surveillance with Renewable Energy”, Dr. Justin Thompson, Chief Operating Officer, Sentry View Systems and Mr. Kerry Starr
- 12837 - “Comprehensive Integration and Interaction of Equipment Used For Remote Site Systems”, Mr. Doug Combs, Director DOD Programs, Berg Companies

2011 Joint Service Power Expo**

May 2 – 5, 2011

Myrtle Beach Convention Center

Myrtle Beach, SC

Tentative Agenda (a/o May 13, 2011)*

Monday, May 2, 2011

9:00 a.m. - 5:00 p.m.	Exhibitor Move-in & Exhibitor Registration* (outdoor displays begin move-in 12noon -5pm) • Exhibit Hall C
9:00 a.m. - 5:00 p.m.	Conference Attendee Registration Check-in* • Ballroom Pre-function Hall of Fame foyer
12:30 p.m. – 6:00 p.m.	Inaugural JSPE "Tee Time" Golf Outing/Get Together • Myrtlewood PineHills course

Tuesday, May 3, 2011

7:00 a.m. - 9:00 a.m.	Exhibitor Move-in Continues • Exhibit Hall C
7:00 a.m. - 5:30 p.m.	Conference Attendee & Exhibitor Registration (continues) • Ballroom Pre-function Hall of Fame foyer
7:00 a.m. - 8:00 a.m.	Continental breakfast • Ballroom Pre-function Hall of Fame foyer
8:00 a.m. – 11:30 a.m.	Opening Session • Ballroom D & E
8:00 a.m. – 8:05 a.m.	Administrative & Welcome Remarks • Marc Gietter, 2011 JSPE Conference Chair • playing of the National Anthem
8:05 a.m. - 8:15 a.m.	Welcome to Myrtle Beach Mayor John Rhodes, Myrtle Beach
8:15 a.m. – 9:00 a.m.	General Session • *Keynote Speaker #1:* Former Congressman Curt Weldon (R-PA)

*times, speakers & room assignments subject to change

***2011 Joint Service Power Conference attendee/exhibit booth personnel badge required to attend all conference sessions & functions*

<u>Tuesday, May 3, 2011 (continued)</u>

9:00 a.m. – 9:30 a.m.	General Session • *Keynote Speaker #2:* • Mr. Bill Heisey, Lockheed Martin
9:30 a.m. – 10:00 a.m.	Coffee Break in the Exhibit Hall • Exhibit Hall C
9:30 a.m. - 5:00 p.m.	**Exhibit Hall Open** • Exhibit Hall C
10:00 a.m. – 11:30 a.m.	General Session • Ballroom D & E *"Update on USMC Expeditionary Power and Energy Acquisition"* • Mike Gallagher, Program Manager Marine Corps Systems Command *"Army Power Needs"* • COL Jay L. Peterson, USA • MAJ Steve Meredith, USA
11:30 a.m. - 1:00 p.m.	**LUNCH w/speaker** • Ballroom A, B & C *"The Federal Budget Process & Why We Need More Technical People in Government"* Former Congressman George Hochbrueckner (D-NY)

Tuesday, May 3, 2011 (continued)

1:00 p.m. - 2:30 p.m. Conference Break-out Sessions

Session	Session 1: Battery Monitoring & Maintenance	Session 2: Micro/Smart Grids 1	Session 3: Strategic Planning for Energy Initiative
Location *(subject to change):*	Ballroom D	Ballroom E	Meeting Room 106-107
Session Chair	Mike Bissonette	Alex Askari	Marc Gietter
Abstract/Presentation	*"New Advances in Lithium Ion Battery Monitoring"*	*"Project Manager Mobile Electric Power Smart Grid Efforts"*	*"DOD-DOE partnering - Moving out on Transitioning Fuel Cells"*
Abstract ID #	12804	12093	12303
Author/Presenter	Mr. Joern Tinnemeyer, Vice President, Research and Development, Cadex Electronic Inc.	Miss Jennifer Whitmore, Electrical Engineer CERDEC C2D Army Power	Mr. Peter Devlin, Market Transformation Team Lead, U.S. Department of Energy (EE-2H) *and* Mr. John Christensen
Abstract/Presentation	*"Battery Management System for Monitoring up to Six Lead Acid Batteries at the Individual Battery and System Levels"*	~~*"Mobile Micro-Grid Management System"*~~	*"High Energy Density Systems (HEDS) R&D Plan"*
Abstract ID #	12809	~~12766~~	12835
Author/Presenter	Dr. David Liu, Vice President Research and Development, HDM Systems Corporation	~~Mr. Cristian Anghel,~~ ~~Staff Scientist R&D,~~ ~~Honeywell~~	Mr. Kyle Werner, Division Manager for Code GXS, Naval Surface Warfare Center Crane Division *and* Ms. Susan Waggoner
Abstract/Presentation	*"Battery Maintenance"*	*"Developing Hybrid and Sustainable Energy Solutions for the Increasing Power and Mobility Needs of the Warfighter"*	*"NSWC Crane, Energy Power & Interconnect Technology Division/ARPA"*
Abstract ID #	L-3	12788	L-1
Author/Presenter	Mr. Mark Abelson , Director-Govt/Military Programs Pulsetech Products Co.	Mr. Dan Madden, PE, CEO/General Manager, Energy Technologies, Inc.	Mr. David Miller, Test and Evaluation Branch Manager, NSWC Crane Division

2:30 p.m. – 3:00 p.m. Coffee Break in the Exhibit Hall

- Exhibit Hall C

Tuesday, May 3, 2011 (continued)

3:00 p.m. – 4:30 p.m. Conference Break-out Sessions (continue)

Session	**Session 4:** **Battery Charging**	**Session 5:** **Micro/Smart Grids 2**	**Session 6:** **Getting Product to the User**
Location *(subject to change):*	Ballroom D	Ballroom E	Meeting Room 106-107
Session Chair	Mike Bissonette	Eric Shields	Don Brockel
Abstract/Presentation	*"Rechargeable Batteries"*	*"The Quest for the Holy Grid"*	*Army Training and Doctrine Command "TRADOC"*
Abstract ID #	L - 13	12351	L-12
Author/Presenter	Mr. Don Brockel Project Leader, U.S. Army CECOM	Mr. Ken Deylami, Lead General Engineer, CERDEC C2D Army Power	COL Paul Roege, USA FORSCOM
Abstract/Presentation	~~*"Austere location battery charging for reduced logistics trail"*~~	*"A123's Advanced Grid Storage: Distributed Generation and Microgrids for Increased Energy Efficiency & Security"*	*"Warfighter Perspective"*
Abstract ID #	~~11707~~	12795	
Author/Presenter	~~Mr. Joe MacLiesh,~~ ~~Vice President Engineering,~~ ~~UltraCell~~	Ms. Kimberly Pargoff, Government Grid Director, A123 Systems	CERDEC Warfighter Support Office
Abstract/Presentation	*"Mobile Charging System"*	*"Gen Set Eliminator - Optimizes Fuel Consumption"*	*"Rapid Fielding, and the Army Safety Release/Safety Confirmation Process"*
Abstract ID #	12127	12808	12838
Author/Presenter	Mr. Rick Silva, Senior Systems Engineer, CME	Mr. Andrew Naukam, VP Technology, Energy Storage Systems, Ultralife Corporation and Dr. Ron Wang	LTC Daniel Rusin, USA (Ret.), Test Manager, DTC, Army Test and Evaluation Command *and* LTC Richard Lonardo, USA (Ret.)

4:30 p.m. - 5:00 p.m. Free Time

5:00 p.m. - 6:30 p.m. **Conference Reception (Exhibit Hall)**

- Exhibit Hall C

Wednesday, May 4, 2011

7:00 a.m. - 5:30 p.m. — Conference Attendee & Exhibitor Registration (continues)

- Ballroom Pre-function Hall of Fame foyer

7:00 a.m. - 8:00 a.m. — Continental breakfast

- Ballroom Pre-function Hall of Fame foyer

8:00 a.m. - 9:30 a.m. — Conference Break-out Sessions (continue)

Session	**Session 7:** **Advanced Battery Systems**	**Session 8:** **USMC Power Initiatives**	**Session 9:** **Generators**
Location ***(subject to change):***	Ballroom D	Ballroom E	Meeting Room 106-107
Session Chair	Sam Stuart	Casey Steigar	Nick Foundos
Abstract/Presentation	*"Squad Power - Advanced Lithium Power Sources"*	*"Small unit power requirements from the customers perspective"*	*"High Power Density Turbine Based Generation Systems"*
Abstract ID #	11769	12784	12078
Author/Presenter	Mr. Jim Hess, Director, Defesne Sales, Saft America, Inc. and Mr. Pat Lyman	Lt Col Michael Bissonnette, USMC (Ret.), L-3 Communications	Mr. Hernando Munevar, President & CEO, Candent Technologies, Inc.
Abstract/Presentation	*"Universal Light Weight Smart Battery for THHR\Wireless Light Weight Smart Battery for Tactical Handheld radio"*	*"Marine Corps Renewable Energy and Micro Gridding Programs"*	*"Man-Portable Tactical Power: Report on Efforts"*
Abstract ID #	11911 &11913	12081	12105
Author/Presenter	Mr. Merdod Badie, Senior Project Manager, Thales Communications Inc.	Mr. Clint Govar, Engineer, MCSC	Mr. S. Paul Dev, President, D-STAR Engineering Corp.
Abstract/Presentation	*"Large Format Lithium Power Cells for Demanding Hybrid Applications"*	*"Alternative Energy Based Expeditionary Power Solutions"*	*"Development of a lightweight, man-portable, heavy-fuel generator"*
Abstract ID #	12785	12125 & 12126	L – 6
Author/Presenter	Mr. Adam Hunt, Manager of Government Programs, ENERDEL	Dr. Carl Kirkconnell, Iris Technology Corporation	Mr. Les Gray, Executive in Residence, QinetiQ North America *and* Andrew A. Pouring, D.Eng. CEO and Chief Technical Officer Sonex Research, Inc.

9:00 a.m. - 4:00 p.m. — **Exhibit Hall Open**

- Exhibit Hall C

*times, speakers & room assignments subject to change

***2011 Joint Service Power Conference attendee/exhibit booth personnel badge required to attend all conference sessions & functions*

Wednesday, May 4, 2011 (continued)

9:30 a.m. – 10:00 a.m. Coffee Break in the Exhibit Hall

- Exhibit Hall C

10:00 a.m. - 11:30 a.m. Conference Break-out Sessions (continue)

Session	**Session 10:** **BA-XX90 Batteries**	**Session 11:** **Fuel Cells I**	**Session 12:** **Renewable Energy 1**
Location ***(subject to change):***	Ballroom D	Ballroom E	Meeting Room 106-107
Session Chair	Mike Brundage	Trent Frady	Clint Govar
Abstract/Presentation	*"Next Generation 5X90 Battery"*	*"OSD Fuel Cell Roadmapping Effort"*	*"Merlin Adapters for Tactical Radios – The New Standard in Power Management"*
Abstract ID #	12102	11909	12124
Author/Presenter	Mr. Carlos Negrete, New Technologies Engineering Manager, SAFT America	Mr. Jim Gucinski	Mr. Ed O'Rourke, Iris Technology Corporation
Abstract/Presentation	*"Recent Advances for Lithium Carbon mono-fluoride Batteries for Portable Applications"*	*"Manhattan Fuel Cell Manufacturing Technology Study"*	*"Design Development and Testing of a Rapidly Deployable Man-Transportable Renewable Energy System"*
Abstract ID #	12777	12071	12111
Author/Presenter	Dr. Gregg Bruce, Chief Scientist, EaglePicher Energy Products	Ms. Rebecca Morris, Product and Applications Engineer, ACI Technologies, Inc. *and* Mr. Carmine Meola	Mr. Eric Shields, Mechanical Engineer, NSWCCD *and* Mr. Alex Askari
Abstract/Presentation	*"Li-CFx/MnO2 Hybrid D-cell with Wide Operating Temperature Range for Military Batteries"*	*"Renewable energy generation and storage for reduced logistics burden"*	*"REMM: Expeditionary Power"*
Abstract ID #	12823	12132	12180
Author/Presenter	Dr. Xinrong Wang, Research Manager, Ultralife Corporation *and* Mr. David Modeen	Ken Pearson President & COO Jadoo Power	Mr. Stephen Nimmer, Director, Engineering Defense Technology Development Oshkosh Corporation

Wednesday, May 4, 2011 (continued)

11:30 a.m. - 1:00 p.m. **LUNCH w/speaker**

- Ballroom A, B & C

  "Removing the Internal Barriers to DoD's Deployment of Energy Efficient Technology"

  - Mr. Kristopher Haag, SES
    Deputy Director,
    Task Force for Business and Stability Operations
    OSD-TFBSO

1:00 p.m. – 2:30 p.m. Conference Break-out Sessions (continue)

Session	**Session 13: Large Format Rechargeable Batteries**	**Session 14: Fuel Cells 2**	**Session 15: Renewable Energy 2**
Location *(subject to change):*	Ballroom D	Ballroom E	Meeting Room 106-107
Session Chair	Mike Brundage	Matt Hutchens	Matthew Huffman
Abstract/Presentation	*"Technical Challenges for Vehicle 12V/24V Lithium Ion Battery Replacement"*	*"JP-8 Compatible Fuel Cell Gensets at Lockheed Martin"*	*"Solar Photovoltaic Tactical Electric Power Systems"*
Abstract ID #	12131	12103	12147
Author/Presenter	Mr. David Skalny, Energy Storage Deputy Team Leader, Ground Vehicle Power & Mobility Directorate, U.S. Army TARDEC	Mr. Steven Sinsabaugh, Lockheed Martin Fellow, Lockheed Martin MS2	Mr. Cao Chung, Chemical Engineer, U.S. Army CERDEC C2D

Wednesday, May 4, 2011 (continued)

1:00 p.m. – 2:30 p.m. Conference Break-out Sessions (continue)

Session	**Session 13 (continued): Large Format Rechargeable Batteries**	**Session 14 (continued): Fuel Cells 2**	**Session 15 (continued): Renewable Energy 2**
Location *(subject to change):*	Ballroom D	Ballroom E	Meeting Room 106-107
Session Chair	Mike Brundage	Matt Hutchens	Matthew Huffman
Abstract/Presentation	*"Integration of NanoPhosphate Prismatic Battery Cells into the XM1124 Hybrid Electric HMMWV"*	*"Reducing Warfighter Load by Improving Energy Density"*	*"Regenerative Solar Power Solutions for Extended Mission Endurance"*
Abstract ID #	12812	12771	12096
Author/Presenter	Dr. Mike Marcel, Government Operations Manager, A123 Systems	Mr. Philip Hassell, Sales and Business Development Manager, SFC Energy, Inc.	Mr. John Hart, Business Development, ABSL Power Solutions Inc.
Abstract/Presentation	*"Large Format Li Ion Replacement Packs/Light Weight, High Power and -40°C Capable Li-ion Battery"*	*"Solid Oxide Fuel Cells to reduce the logistic burden of resupplying the Warfighter through point of need power generation"*	*"Utilization of a Ducted Wind Turbine in a Trailer-Mounted Renewable Energy Micro-grid"*
Abstract ID #	12187 &12188	12801	12799
Author/Presenter	Dr. Hisashi Tsukamoto, CEO, CTO, Quallion LLC *and* Mr. Vincent Visco	Mr. Jon Rice, Business Segment Leader, Ultra-AMI	Mr. Mark Matthews, VP of Sales and Marketing, WindTamer Corporation *and* Mr. Adeeb Saba

2:30 p.m. – 3:00 p.m. Coffee Break in the Exhibit Hall

- Exhibit Hall C

Wednesday, May 4, 2011 (continued)

3:00 p.m. – 4:30 p.m. Conference Break-out Sessions (continue)

Session	**Session 16:** **On-Board Vehicle Power (OBVP) 1**	**Session 17:** **Building Government Industry Relationships**	**Session 18:** **Renewable Energy 3**
Location *(subject to change):*	Ballroom D	Ballroom E	Meeting Room 106-107
Session Chair	Jon Carpenter	Kyle Werner	Malar Motley
Abstract/Presentation	~~*"Comparing Methods of Providing On-Board Vehicle Power on a Tactical Vehicle"*~~	*"Advancing Renewable Energy Technology Commercialization through Federal, State and Local Collaborations"*	*"Lightweight and Low Cost Solar"*
Abstract ID #	~~12149~~	12076	12159
Author/Presenter	~~Mr. Gus Khalil,~~ ~~Team Leader,~~ ~~US Army TARDEC~~ ~~*and*~~ ~~Dr. Mike Marcel~~ ~~*and*~~ ~~Dr. Wesley Zanardelli~~ ~~*and*~~ ~~Dr. Abdul Masrur~~ ~~*and*~~ ~~Ms. Janie Arafat~~	Mr. Russ Keller, Vice President, Advanced Technology International	Dr. Randall Olsen, Physicist, SPAWAR Systems Center Pacific
Abstract/Presentation	*"Oshkosh On-Board Vehicle Power Systems: Advancement from Heavy to Light Vehicles'*	*"Rapid Fielding, and the Army Safety Release/Safety Confirmation Process"*	*"Training Center Petaluma Solar Power"*
Abstract ID #	12178	12302	12160
Author/Presenter	Mr. Nader Nasr, Senior, Chief Engineer, Adv Products Group, Oshkosh Corporation	Mr. Glen Bowling, Vice President Sales, Saft Specialty Battery Group	CDR Jeff Good, USCG *and* CAPT Chris Hall *and* Mr. Tony vanWinden
Abstract/Presentation	*"Office of Naval Research Maneuver Science and Technology Programs in Fuel Efficiency and Battlefield Power"*		*"Development of Flexible, Lightweight CIGS Photovoltaic Power Solutions for Today's Military"*
Abstract ID #	12834		12829
Author/Presenter	Mr. Michael Mimnagh, Engineer, Naval Surface Warfare Center		Mr. Ashu Misra, Senior Vice President Sales & Corporate Development Ascent Solar Technologies *and* Mr. Brian Blackman, Director of Corporate Development

Wednesday, May 4, 2011 (continued)

3:00 p.m. – 4:30 p.m. Conference Break-out Sessions (continue)

Session	**Session 16 (continued): On-Board Vehicle Power (OBVP) 1**	**Session 17 (continued): Getting Product to the User**	**Session 18 (continued): Renewable Energy 3**
Location *(subject to change):*	Ballroom D	Ballroom E	Meeting Room 106-107
Session Chair	Jon Carpenter	Don Brockel	Malar Motley
Abstract/Presentation	*"Modeling and Simulation of an OBVP Enhanced Vehicle to Improve Fuel Economy\On-Board Vehicle Power: Past, Present and Future"*	~~*"Shelf life issues with Bryn tronics on batteries and Harris suppliers"*~~	
Abstract ID #	12344 & 12345		
Author/Presenter	Mr. Gary Grider, Senior Project Manager, DRS Test and Energy Management	~~Mr. Joseph Cargile Packaging, DLA Land and Maritime Team Lead Columbus~~	

4:30 p.m. - 5:00 p.m. Free Time

5:30pm/5:45pm/6:00pm Shuttle Busses Depart Sheraton for off site location (Margaritaville)*

6:00 p.m. - 8:00 p.m. **Off-Site Networking Reception***
Shuttle bus service will be provided and/or is within walking distance

7:30pm/7:45pm/8:00pm Shuttle Busses Depart Margaritaville for return to Sheraton*

8:15pm last bus departs Margaritaville for return to Sheraton*

Thursday, May 5, 2011

7:00 a.m. - 11:30a.m. Conference Attendee & Exhibitor Registration (continues)

- Ballroom Pre-function Hall of Fame foyer

7:00 a.m. - 8:00 a.m. Continental breakfast

- Ballroom Pre-function Hall of Fame foyer

Thursday, May 5, 2011 (continues)

8:00 a.m. - 9:30 a.m. Conference Break-out Sessions (continue)

Session	**Session 19:** **Micro/Smart Grids 3**	**Session 20:** **OBVP- 2**	**Session 21:** **Energy for Garrisons**
Location *(subject to change):*	Ballroom D	Ballroom E	Meeting Room 106-107
Session Chair	Traci Myers	Dave Miller	Matt Hutchens
Abstract/Presentation	*"Fuel Consumption Model for Tactical Operations Centers (TOCs)"*	*"Advanced Power Systems for Enhanced Capability and Fuel Economy"*	*"Electric Vehicle Grid Integration for Sustainable Military Installations"*
Abstract ID #	12143	L – 9	12073
Author/Presenter	Ms. Jennifer Barker SURVICE Engineering Company	CAPT Lynn Petersen, USN, Deputy Director, PMS 320 (Electric Ships Office NAVSEA	Mr. Mike Simpson, Engineer, National Renewable Energy Lab (NREL)
Abstract/Presentation	*"A demonstration of intelligent control technology in tactical power grids"*	*"Permanent Magnet Generators for On Board Vehicle Power"*	*"Compendium of Technical Information on Renewable Energy for Department of Defense Facilities and Bases"*
Abstract ID #	12270	12448	12114
Author/Presenter	Dr. Darrell Massie, Chief Technology Officer, Intelligent Power & Energy	Mr. James Burns, P.E., Director of Engineering, DRS Power Technology, Inc.	Mr. Benjamin Craig, Senior Chemical Engineer, Alion Science and Technology
Location *(subject to change):*	Ballroom D	Ballroom E	Meeting Room 106-107
Session Chair	Traci Myers	Dave Miller	Matt Hutchens
Abstract/Presentation	*"IECS--an Innovative Micro-grid Solution for Tactical Operations"*	*"Integrating Power Plants Into Powertrains"*	*"Using Fuel Cells for Building Power"*
Abstract ID #	12796	12346 & 12347	*L- ??*
Author/Presenter	Mr. Pat Jacob Business Development Manager Williams-Pyro, Inc. *and* Mr. Peter Gardner	Brent Brzezinski, Ph.D., Engineering Specialist, DRS Test and Energy Management	Ruth F. Cox President and Executive Director Fuel Cell and Hydrogen Energy Association

9:00 a.m. - 10:30 a.m. **Exhibit Hall Open**

- Exhibit Hall C

9:30 a.m. – 10:00 a.m. Coffee Break in the Exhibit Hall

- Exhibit Hall C

Thursday, May 5, 2011 (continues)

10:00 a.m. - 11:30 a.m. Conference Break-out Sessions (continue)

Session	Session 22: Hybrid Systems	Session 23: OBVP- 3	Session 24: Power to Remote Locations
Location *(subject to change):*	Ballroom D	Ballroom E	Meeting Room 106-107
Session Chair	Matthew Huffman	Nick Foundos	Sue Waggoner
Abstract/Presentation	*"The Alternative Energy Coalition: A Struggle for Power in the Expeditionary Environment"*	*"Unique Heavy Fuel Rotary Engine Generator Development"*	*"Pulse Energy Management System – Real Time Optimization of Remote Deployment Energy Systems"*
Abstract ID #	11848 & 11849	12115	12813
Author/Presenter	Mr. Thomas Lederle, Vice President Product Development, NEST Energy Services	~~Mr. Andrew Biske,~~ ~~Engineer,~~ ~~US Army TARDEC~~ ~~*and*~~ ~~Dr. Darin Kowalski~~	Mr. Bruce Cullen, Manager - Remote Communities, Pulse Energy
Abstract/Presentation	*"Optimizing Generator Efficiency with Energy Storage Technologies"*	~~*"Power Management Improvements for New and Existing Vehicles"*~~	*"SentryPOST Solution for Remote Surveillance with Renewable Energy"*
Abstract ID #	12064	~~12130~~	12825
Author/Presenter	Mr. William Moorehead, Chief Operating Officer, Earl Energy, LLC	~~Mr. Dave Allen,~~ ~~Senior Develop Engineer/RSM,~~ ~~Engineered Machined Products, Inc.~~ ~~*and*~~ ~~Mr. Ralph Bedogne~~	Dr. Justin Thompson, Chief Operating Officer, Sentry View Systems *and* Mr. Kerry Starr
Abstract/Presentation	*"Reducing Fuel Consumption with Hybrid Renewable/Conventional Micro-grids."*	*"Polaris REX Technology"*	*"Comprehensive Integration and Interaction of Equipment Used For Remote Site Systems"*
Abstract ID #	12066	12836	12837
Author/Presenter	COL Albert Zaccor, USA (Ret.) CEO, Solar Stik	Mr. Stacy Stewart, Director, Powertrain Engineering Polaris Industries, Inc. *and* Mr. Patrick Weldon	Mr. Doug Combs, Director DOD Programs, Berg Companies

11:30 a.m. Adjourn

12:00 p.m. – 5:30 p.m. Military Powers Sources Committee Meeting (50 pp)
Room 202-204

Thursday, May 5, 2011 (continues)

10:30 a.m. - 4:00 p.m. Exhibitor Move-out

2011 Exhibit Schedule: *(check back at* www.ndia.org/exhibits/1670 *for changes & updates)*

Exhibitor Move-In: Mon, May 2nd - 9:00am - 5:00pm (outdoor displays begin move-in 12noon -5pm)

Exhibits Open:

Tues, May 3rd - 10:00am - 5:00pm with reception in exhibit hall 5:00pm - 6:30pm

Wed, May 4th 9:00am - 4:00pm

Thurs, May 5th 9:00am - 10:30 a.m.

Exhibitor Move-Out: Thurs, May 5th 10:30 a.m. - 4:00pm

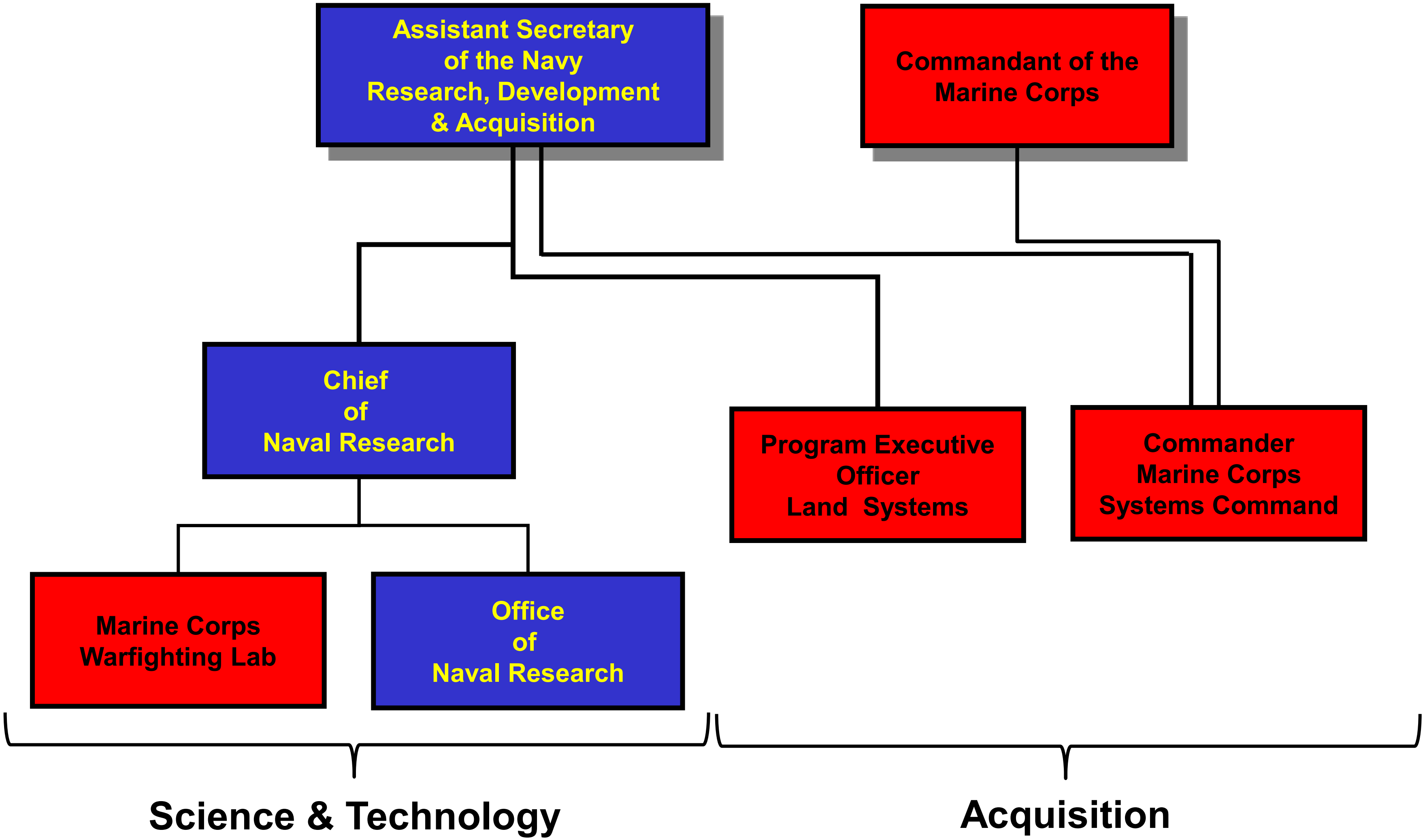
USMC Acquisition Initiatives in Tactical Electric Power

Michael Gallagher
Program Manager - Expeditionary Power Systems
Marine Corps Systems Command

Discussion Topics

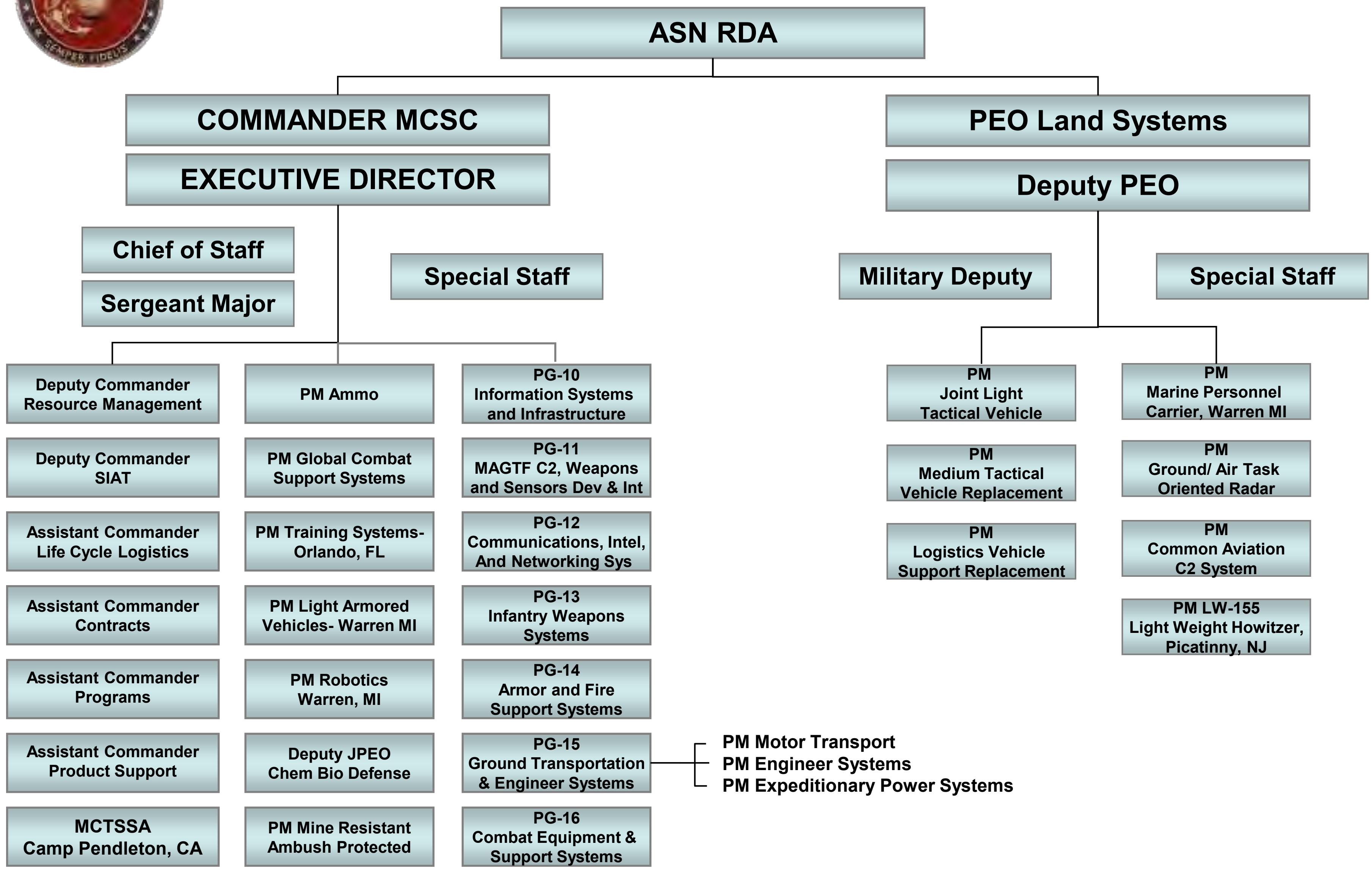
- **Organizations**
- **USMC Requirements**
- **New initiatives for USMC Power & Energy**
- **New acquisition policies and impacts**
- **Points of Contact**

USMC Organizations in Power and Energy

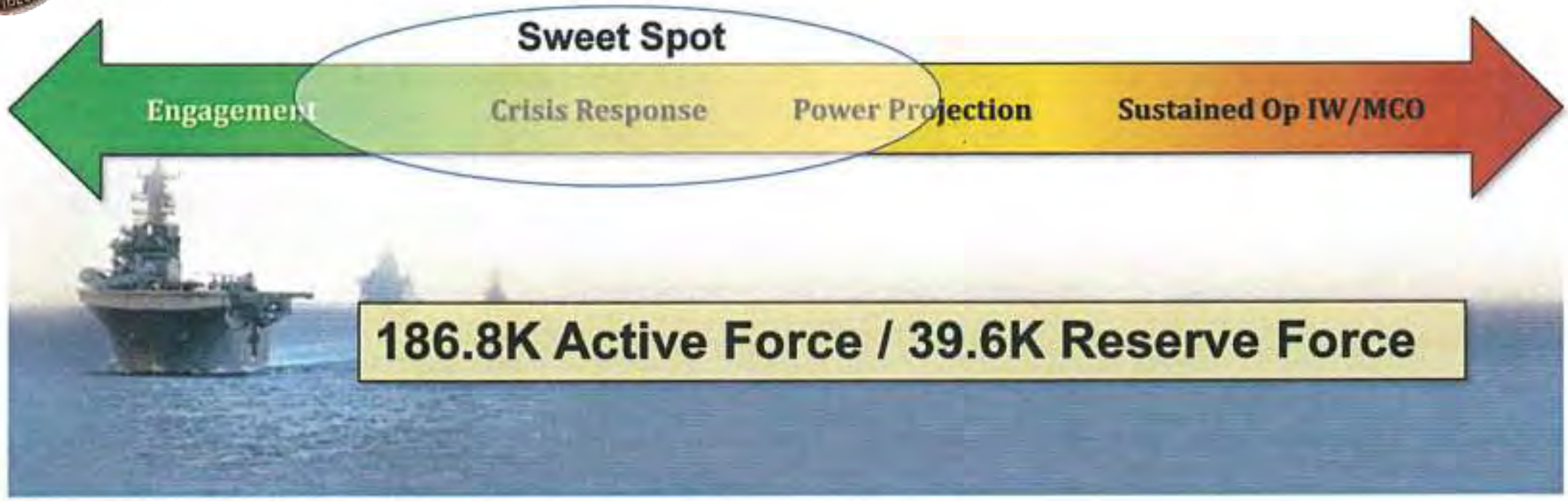


UNCLASSIFIED

USMC Acquisition Organizations



USMC Force Structure Review



- **7.5% reduction of force, but 9% reduction in logistics**
- **Larger than Special Operations Forces, but more expeditionary than conventional Army units**
- **Able to engage and respond quickly – often from the sea.**

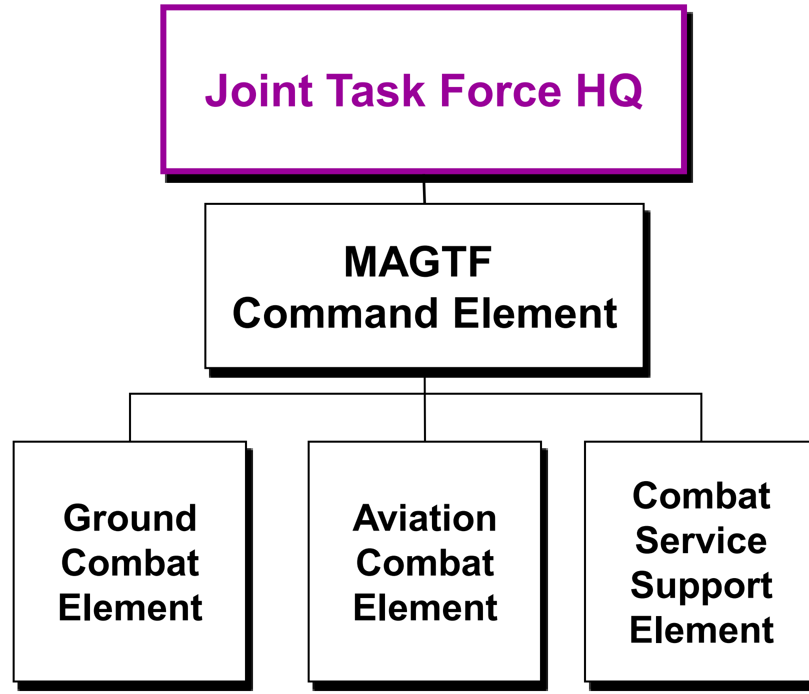
Strategically mobile, middleweight force

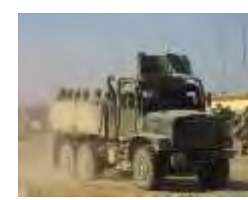
Optimized for rapid crisis response and forward-presence

Back to Amphibious / Expeditionary Roots

MARINE AIR-GROUND TASK FORCES

- USMC always works within the organizational framework and alignment to the Joint mission
- MAGTFs are self-contained
- MAGTFs bring their air, ground, and logistics support elements with them





USMC is, and will continue to be, inherently a Naval based force.

MAGTFs Come In Various Sizes

Special Purpose MAGTF — ~ As required (Inf Co ~ 72 hrs Sustainment)

Marine Expeditionary Unit (MEU) — ~ 1500 – 3K Marines (15 days of supply)

Marine Expeditionary Brigade (MEB) — ~ 3 - 20K Marines (30 days of supply)

Marine Expeditionary Force (MEF) — ~ 20 - 90K Marines (120 days of supply)

Scalable, Tailorable Combined-Arms Teams
There is no “One Size Fits All” solution

Implications to Power & Energy

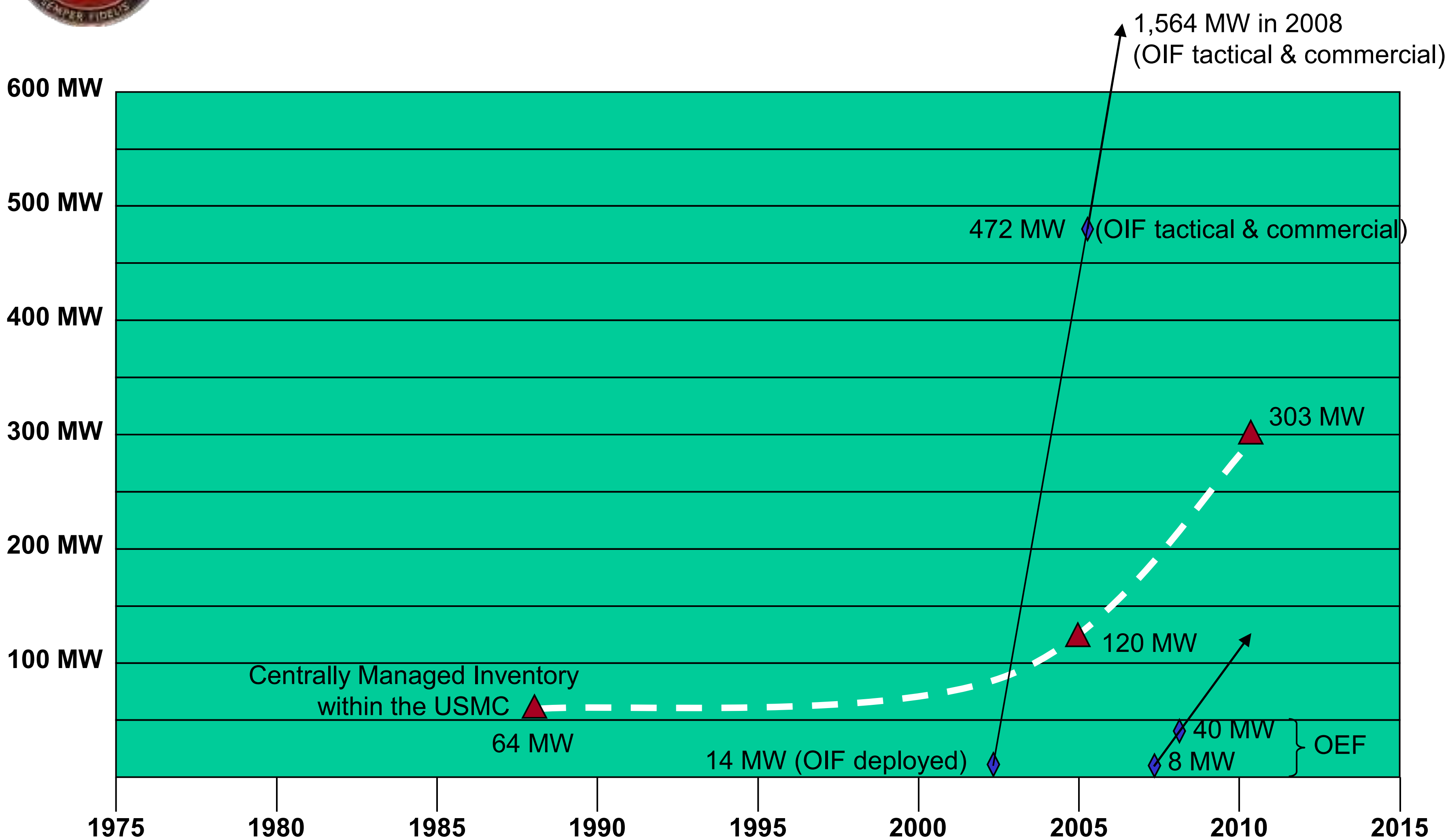
- **<u>Space</u> and <u>Weight</u> are at a premium due to lift restrictions**
  - Air
  - Sea
  - Land
- **Efficiency of energy use for deployed forces**
- **Unique transportation requirements**
  - All equipment must be capable of deploying via ship, air or tactical vehicle
  - High corrosion environment of surf transit and coastal storage
  - Electromagnetic interference from shipboard systems
  - Special restrictions for shipboard stowage / transport (Lithium Batteries)
  - Supply / resupply is from the Naval / Pre-Positioned Forces

Key Transportability Drivers

<u>Individual Marine (carried):</u>	Assault Load < 75#, Existence < 150#
<u>Lifted by Marines / Loose Cargo:</u>	One person lift – 44 pounds
<u>Requiring Forklift / Material Handling:</u>	> 400 pounds
<u>HMMWV Trailer Towable:</u>	< 2700 pounds
<u>Medium Tactical Truck Carried:</u>	< 7 tons (off road), 10 tons (on road)
<u>Heavy Tactical Truck Carried:</u>	< 16 tons (on road)
<u>MV-22 Tilt-Rotor Lift:</u>	< 4 tons (internal)*, 7.5 tons (external)
<u>CH-53 Helicopter Lift:</u>	< 5 tons (internal)*, 14 tons (external)

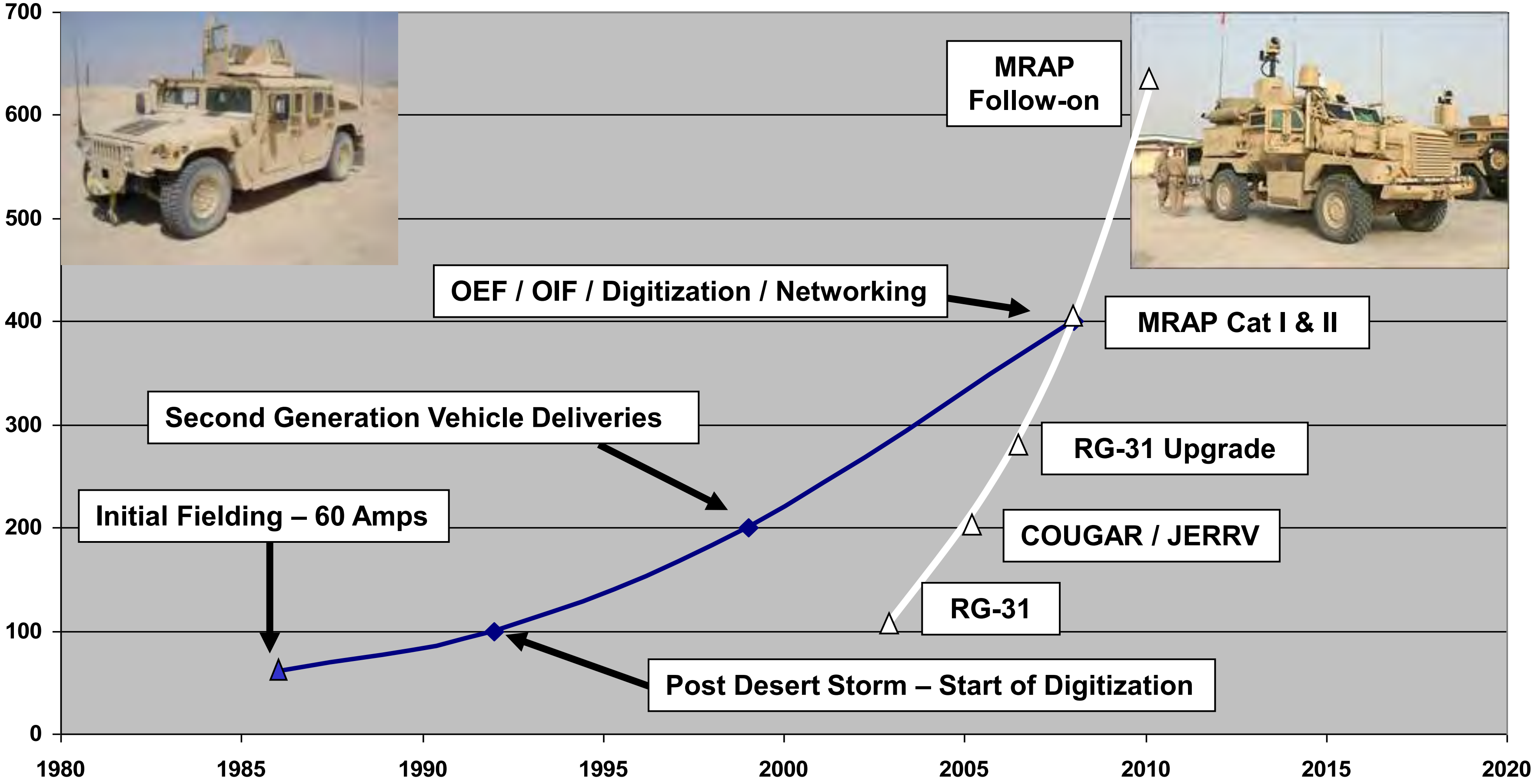
* psi limitations on floor apply

USMC Power Generation Capability



Vehicle Power Needs

Alternator Amperage Rating on HMMWV / MRAP at 28 VDC



What's Consuming Power

Counter IED - Electronic Warfare

Counter IED - Mine Rollers

Communications

Situational Awareness - ISR

Counter IED – Thermal / IR

Remote Operated Weapons

Situational Awareness - BFT

Situational Awareness
Drivers Vision Enhancement

Situational Awareness
Position Location/Reporting

Situational Awareness
Exterior Lighting

Individual Marine Power Requirements

UNCLASSIFIED

Secretary of the Navy Energy Goals

New Requirements for Acquisition Processes

- Mandatory evaluation factors used when awarding contracts for platforms, weapon systems, and buildings will include: Lifecycle energy costs, Fully-burdened cost of fuel, Contractor energy footprint

Sail the "Great Green Fleet"

- DON will demonstrate a Green Strike Group in local operations by 2012 and sail it by 2016

Reduce Petroleum Use in Non-Tactical Vehicles

- By 2015, DON will reduce petroleum use in the commercial fleet by 50%

Increase Alternative Energy Ashore

- By 2020, DON will produce at least 50 percent of shore-based energy requirements from alternative sources

Increase Alternative Energy Use Navy-wide

- By 2020, 50 percent of total DON energy consumption will come from alternative sources

Secretary of the Navy Energy Goals

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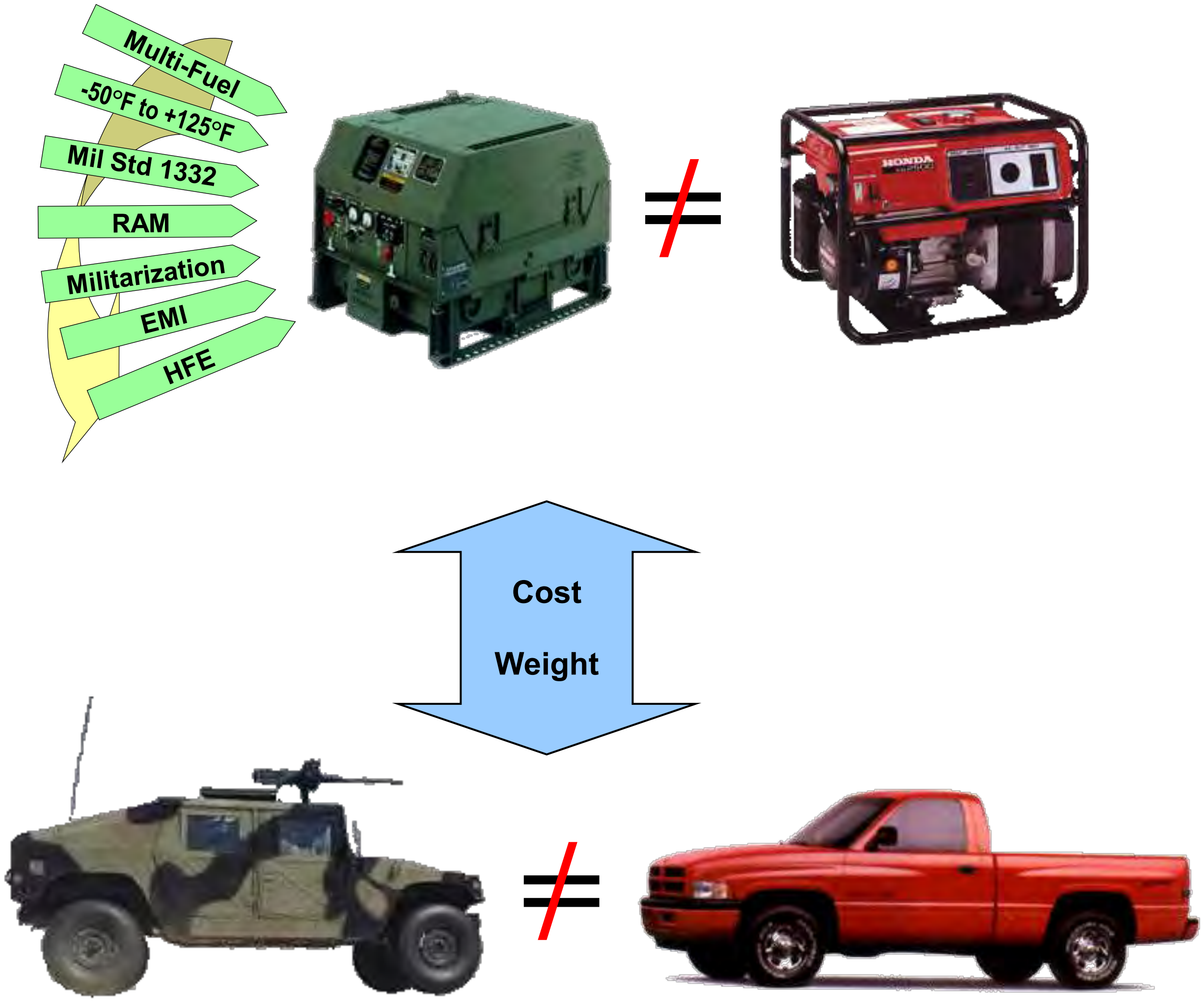
Military Vs. Commercial

Critical Military Features

- Diesel/JP-8 (DoD Policy)
- Environmental Extremes
- Excellent Power Quality
- High Reliability
- Ruggedized
- 24 Volt
- Battlefield Survivability
  - NBC
  - IR
  - Aural
  - EMP Hardening
- Rated Power at Altitude
- Paralleling / Syncing
- Aux Fuel ports



Mobile Electric Power

DOD Standard Generators

USMC Unique Generators

Tools / Customer Support

Integrated Trailer ECU - Generator

Power Distribution

Floodlight Sets

Environmental Control Equipment

Environmental Control Units

Special Customer ECUs

Field Refrigeration

Water Chilling / In-Field Ice Making (food service, mortuary affairs)

Tools / Customer Support

Advanced Power Sources

Radio Power Adaptors

Power Supplies

Renewable Energy

On-Board Power

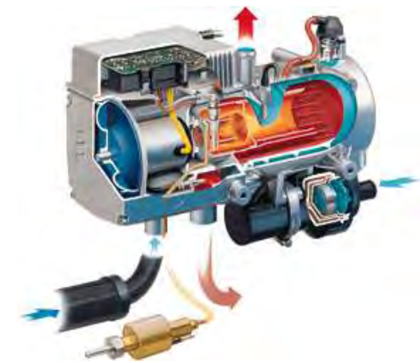
Battery Management / Sustainment Systems

Science and Technology

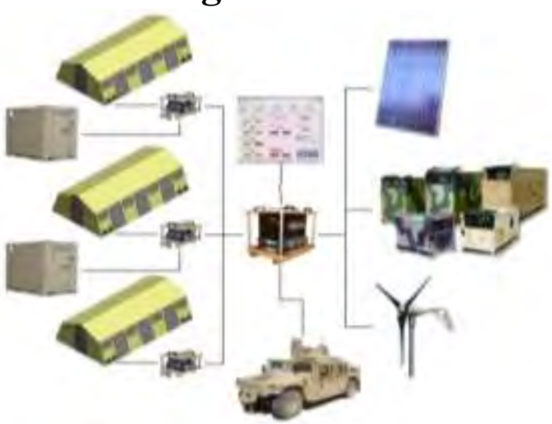
Power Generation

Energy Storage

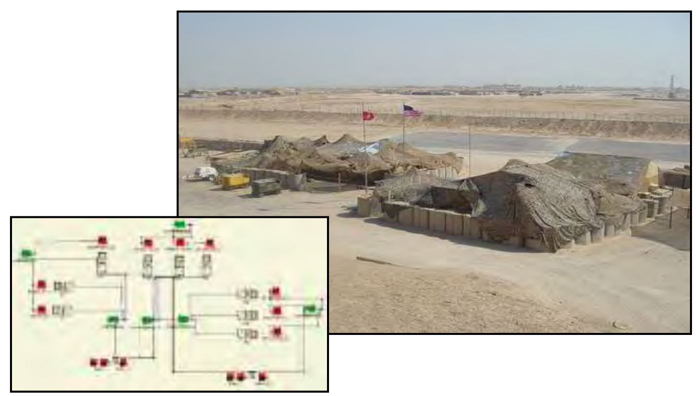
Environmental Control



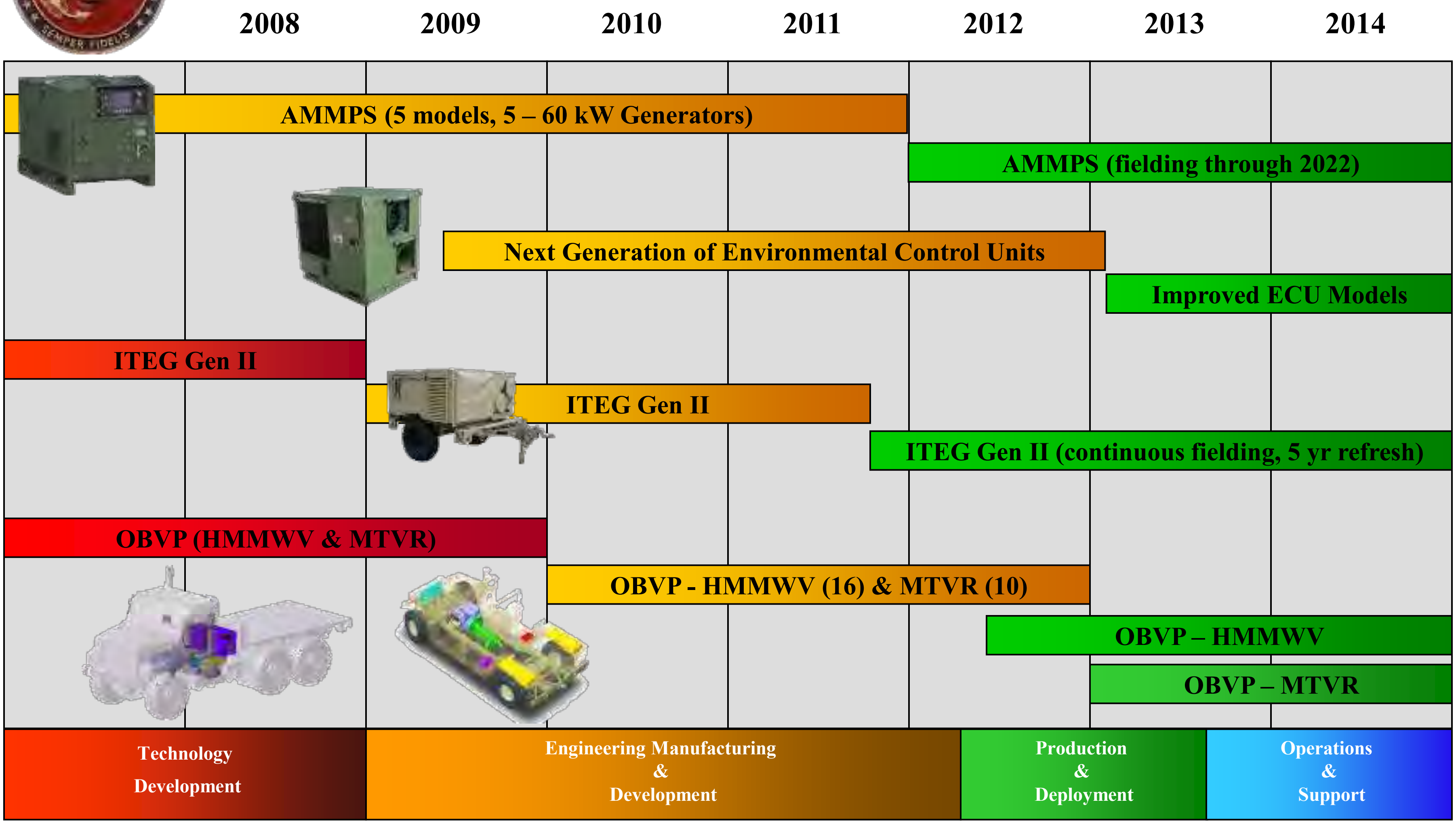
Power Management / Micro Gridding



Experimentation, Modeling, and Tools



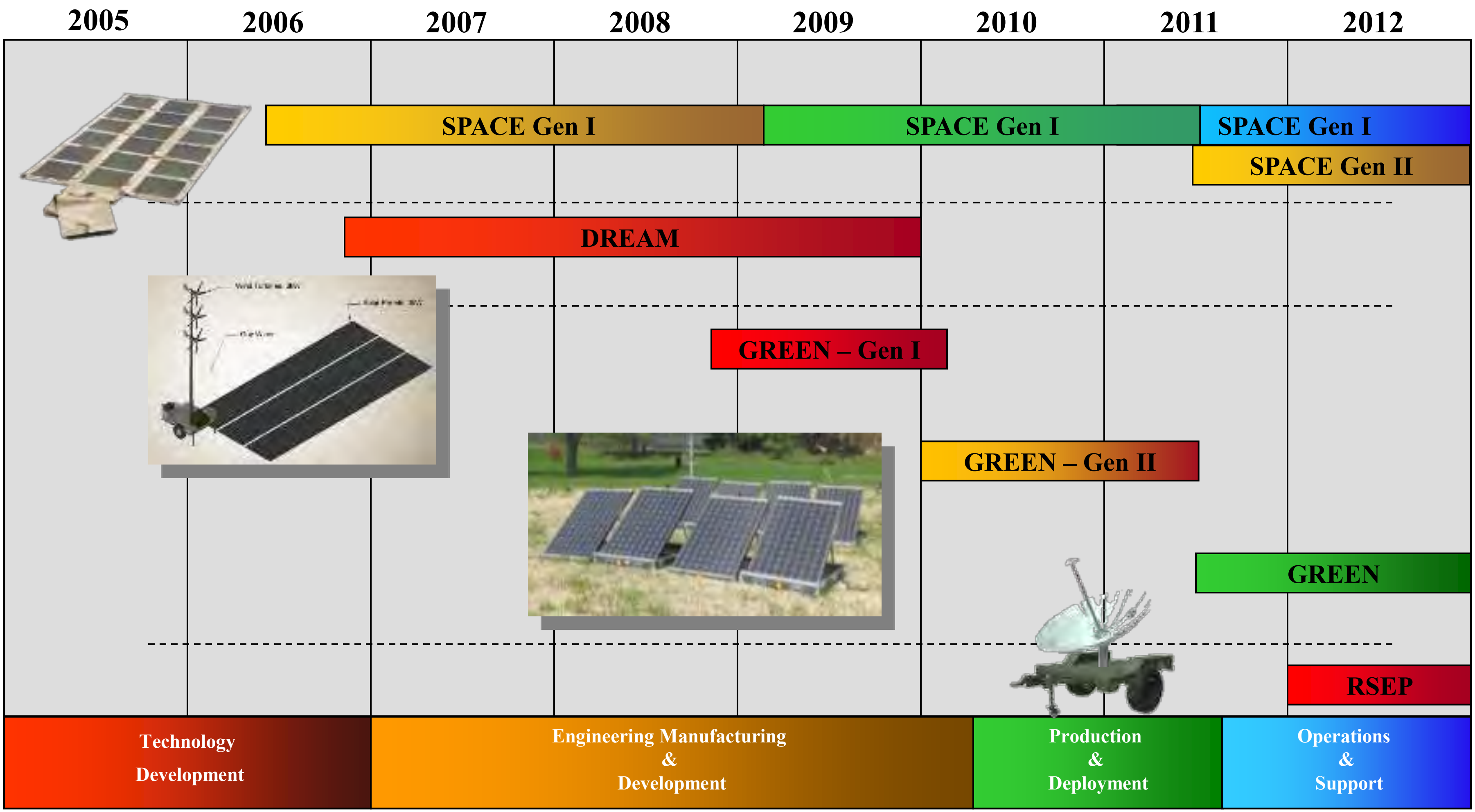
Power / Energy Efficiency Initiatives



AMMPS – Advanced Medium Mobile Power Sources
ECU – Environmental Control Unit

ITEG - Integrated Trailer – Environmental Control - Generator
OBVP – On-Board Vehicle Power Systems

USMC Renewable Energy Efforts



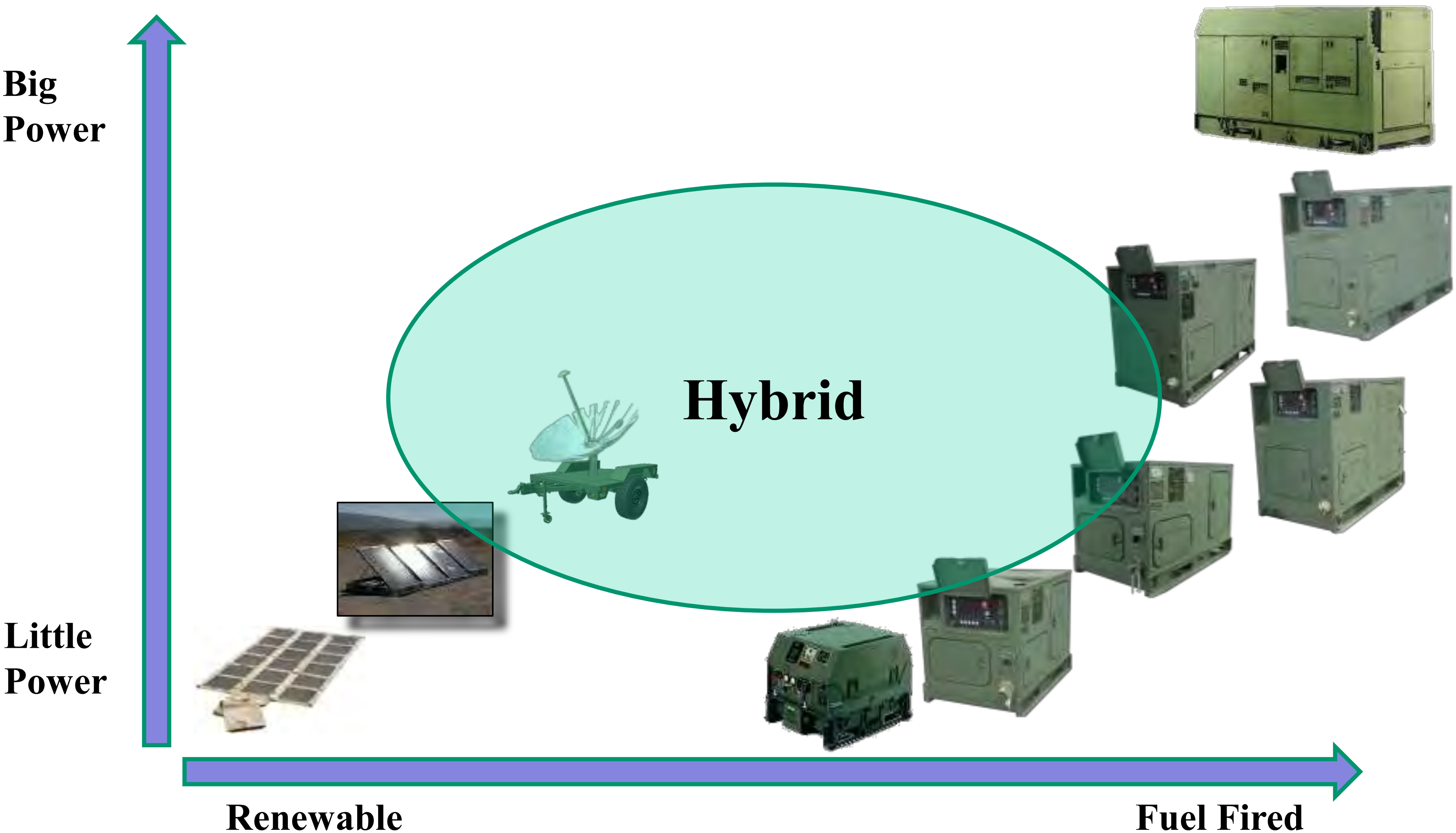
SPACE – Solar Power Adaptor for Communications Equipment (30 Watt continuous)
GREEN – Ground Renewable Expeditionary Energy Network (300 Watt continuous)
DREAM – Deployable Renewable Alternative Energy Module (1.5 kW continuous)
RSEP – Renewable Sustainable Expeditionary Power (3-5 kW continuous)

USMC Renewable Energy Efforts

USMC Calculations for Renewables

- Daily energy content (kw-hrs) is approximately 1/5 of the solar power collection capability
  - GREENS collects 1.6 kW solar power peak, system rated for 300W
  - Batteries rated for 60-70% energy capacity during 24 hr discharge cycle
  - More battery storage / less discharge will extend battery system life
- Currently cannot compete with fuel fired generators on dollars per kW-hours basis for purchase price (possibly life cycle cost)
- But on pound-for-pound resupply (fuel), renewables become competitive in 3-6 months
  - Better on low power side, worse on high power side
- Fully burdened cost of fuel is critical factor

Future Directions



2011 / 2012 Business Opportunities

- Rugged Power Supply with World Wide Power Input
- Improved AN/PRC-117F Radio Power Adaptor
- PRC-152 Stay-Alive Battery Adaptor
- GREENs RE-Buy
- Second Generation Man-Portable Solar Power Adaptor
- Renewable Sustainable Expeditionary Power (ONR)
- Intelligent Small Unit Power (NSWC-Carderock)
- Family of Energy Efficient Environmental Control Units
- MCWL EMO Limited Objective Exercise 2012
- Office of Naval Research – Broad Agency Announcement
- ~~Microgrid~~

Acquisition Policy Changes

DOD Influence:

- Target Affordability / Mandate Affordability as a requirement
- Shorter Program Timelines
- Fixed Price type contracts
- Competition at each program milestone
- Remove obstacles to competition (buy technical data / open systems)

Navy / USMC Influence:

- (N) Contractual Key Performance Parameter(s) for Energy Efficiency
- (N) Modified Source Selection Processes (Technical / Past Performance)
- (MC) Increase Fuel Efficiency
- (MC) Lighten the MAGTF / Equipment Oversight Board
- (MC) Limitations on Sole Source Contracting
- (MC) Use of bid-samples & testing to support source selection

Points of Contact

- PM_EPS@usmc.mil

- www.onr.navy.mil
- www.mcwl.usmc.mil
- www.marcorsyscom.usmc.mil/sites/pmeps

Backup Slides

Detailed Charts

of

Business Opportunities

Stay Alive Power Adaptor

Solicitation / Procurement

- Issuing Activity:
    - Marine Corps Systems Command (M67854)
- Planned Request for Proposal:
    - June 2011 (planned)

Technical Description

- Provide bulk charging and bulk-power adaptor to AN/PRC-152 radios
- Prevent loss of crypto-fill if main battery is discharged (long term storage, MPF)
- Integrated transit case and charger concept
- AC and DC power input
- Plan to use Statement of Objectives:
    - Will have a set # of Critical Requirements that must be met
    - Remaining requirements are *Desired / Value Added*
    - Vendor offered Value Added features also solicited

Environmental Control Units

Current articles

Solicitation / Procurement

- Issuing Activity:
  - Marine Corps Systems Command (M67854)
- Request for Information:
  - June 2010 & November 2010
- Request for Proposal:
  - September 2011 (planned)

Technical Description

- Next family of systems to support:
  - Rigid wall shelters - 9K and 18K BTU/hr
  - Soft wall shelters - 80K to 100K BTU/hr
  - Special applications - 400 Hz models
  - Highly Mobile Applications - DC powered
- Key feature: Energy Efficiency
- Solicitation plans to use:
  - Performance Specification
    - Required attributes
    - Desired attributes
    - Interface Specification
  - Statement of Work
    - Deliverable products & services
    - Data items

Family of USMC Power Supplies

Current
Ruggedized Power Supply (RPS)

Current
Benchtop Power Supply (BPS)

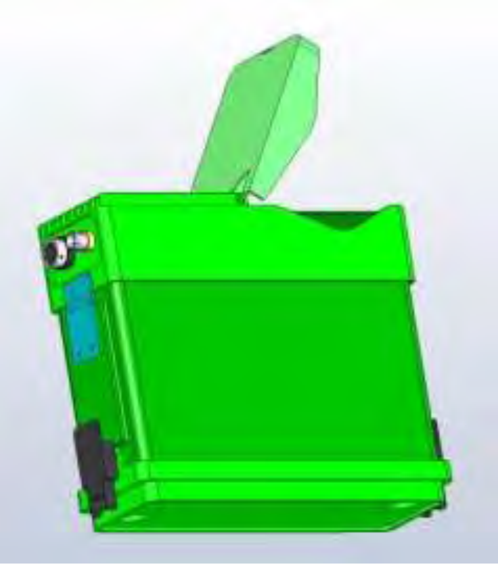
Solicitation / Procurement

- Issuing Activity:
  - Marine Corps Systems Command (M67854)
- Request for Information:
  - RPS: Summer 2010
- Request for Proposal:
  - BPS: Completed
  - RPS: July 2011

Technical Description

- Benchtop Power Supply (BPS):
  - 0-40 Volts DC Out
  - 25 Amps Out
  - 120 VAC, 60 Hz In (required)
  - 90-240 VAC, 50-400 Hz in (desired)
  - Performance Specification based
  - GSA competition
  - Bid Samples required with proposal
  - No R&D, right to Production
- Ruggedized Power Supply (RPS):
  - 0-30 Volts DC Out
  - 60 Amps Out
  - 90-240 VAC, 50-400 Hz In required
  - Performance Specification based
  - Open Competition
  - Defense Acquisition Challenge funded
    - R&D phase
    - Production options

AN/PRC-117F Radio Power Adaptor



NOTIONAL

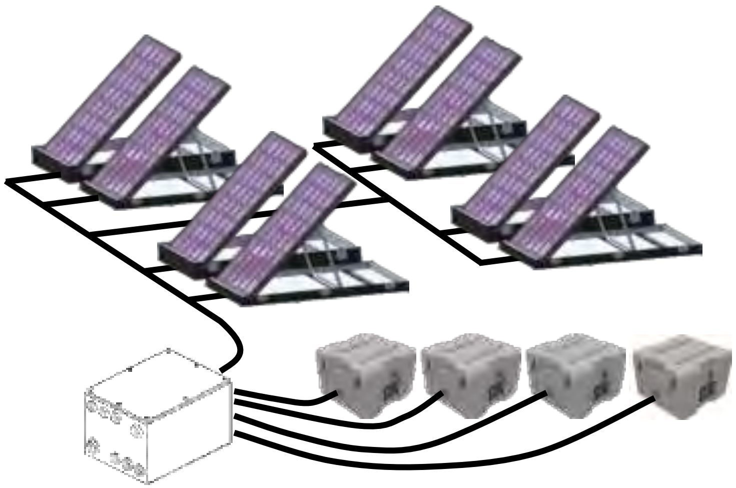
Solicitation / Procurement

- Issuing Activity:
  - Marine Corps Systems Command (M67854)
- Request for Proposal:
  - September 2011 (planned)

Technical Description

- Radio Power Adaptor to allow the 24Volt AN/PRC-117F Tactical Radio to operate from multiple input power sources:
- Input: 120VAC, 60 Hz (required)
- Input: Worldwide power (desired)
- Form Factor: Attach securely to radio
- Military battery for UPS function
  - BA-5590, BA-5390, BB-2590
- Export up to 5 amps at 24VDC
- 5-year contract, up to 5000 units purchased

Ground Renewable Expeditionary Energy Network



Solicitation / Procurement

- Issuing Activity:
  - Marine Corps Systems Command (M67854)
- Draft Solicitation:
  - April 2011
- Request for Proposal:
  - Summer 2011 (planned)

Technical Description

- Follow-On procurement of additional systems (following original performance specification)
- Will work with separately procured Integrated Solar Panel / Case Assembly
- DC Output power with distribution kit
- Key Performance parameters:
  - 300 watts continuous over 24 hour day
  - 1000 watt peak power
  - Lithium Ion Battery (backup Lead Acid)
  - Hybrid generator integration
- Up to 500 articles to be purchased

Man-Portable Solar Power Adaptor II

Current System

Technical Description

- Current Solar Power Adaptor for Communications Equipment (SPACES) highly successful in deployment to OEF
- Next generation system will be required
- Future capability set (notional) to include:
  - < 10# weight (less battery, case)
  - Multiple folding panels
  - BB-2590/U battery charger
  - AA battery charger
  - USB power port
  - AN/PRC-152, -153, -117F adaptors
  - DC-AC inverter
  - AC charging plug, DC NATO plug
  - Hard case for full suite
  - Soft case for deployed sub-set
  - Backward compatible with SPACES

Solicitation / Procurement

- Issuing Activity:
  - Marine Corps Systems Command (M67854)
- Request for Information:
  - Summer 2011
- Request for Proposal:
  - Early 2012

Experimental Forward Operating Base (ExFOB)

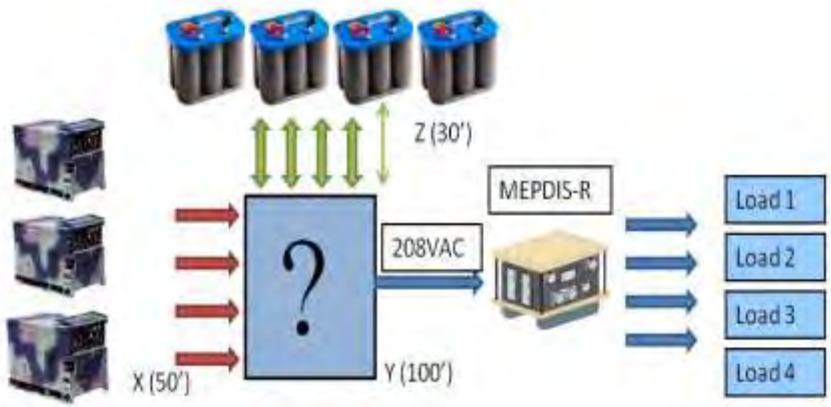
Solicitation / Procurement

- Sources Sought Notice:
  - M00264-11-I-0209
  - Issued: 14 March 2011
  - Responses due: 29 April 2011

Technical Description

- Previous USMC ExFOBs conducted:
  - Quantico VA – Winter 2010
    - Power Generation
    - Efficient Shelters
    - Expeditionary Water
  - 29 Palms CA – August 2010
    - Efficient Shelters
    - Alternate Power Generation
    - Alternate Cooling sources
- Next ExFOB
  - 29 Palms CA – August 2011
- Technology Focus Areas:
  - Tactical Vehicle Fuel Efficiency
  - Concentrated Solar Harvesting
- Vendor funded participation
- Government will instrument & measure

Intelligent Small Unit Power



NOTIONAL

Solicitation / Procurement

- Issuing Activity:
  - Naval Surface Warfare Center (N00167)
- Request for Information:
  - TBD
- Request for Proposal:
  - TBD (2011)

Technical Description

- Collaborative effort between:
  - OSD (DDR&E)
  - Office of Naval Research
  - Marine Corps Systems Command
  - Naval Surface Warfare Center (Carderock Division)
- Rapidly develop / demonstrate a capability for electric power generation and tactical gridding at the small unit level
- Less than 50 kW electric power continuous
- Existing components in military inventory
- 1 year effort to hardware demonstration

Renewable Sustainable Expeditionary Power

NOTIONAL

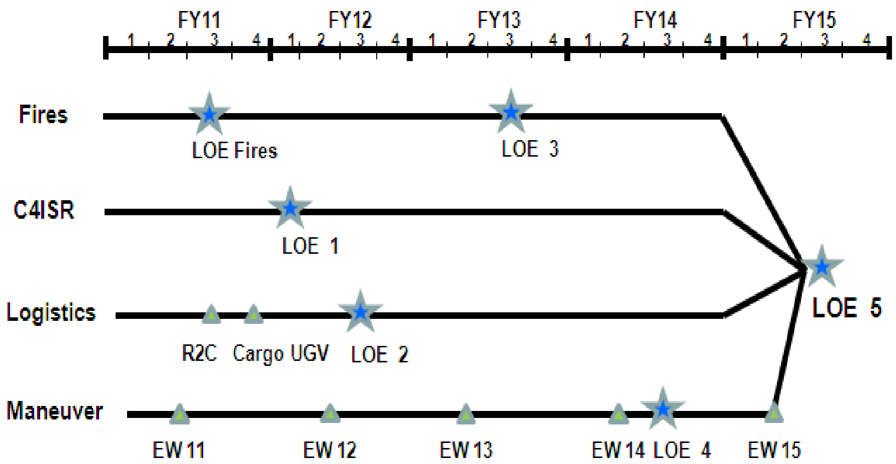
Solicitation / Procurement

- Issuing Activity:
  - Office of Naval Research
- Broad Agency Announcement Release:
  - 15 December 2010
- White Papers Due:
  - 8 April 2011

Technical Description

- Announcement: ONRBAA11-002
- Seeking highly deployable, renewable-based, 3 kW power systems with ability to transition at TRL 6
- Shall employ sustainable energy strategies, energy storage, and liquid fuels, in a hybrid concept to generate power and achieve 40% savings over existing, comparable size DoD power systems.
- Focus Areas:
  - Fuel consumption
  - Noise levels
  - Cost of ownership
  - Maintainability
  - Deployability

MCWL EMO LOE #2 Experiment



Solicitation / Procurement

- Issuing Activity:
    - Marine Corps Warfighting Lab (M67854)

- Source Sought Announcement Released:
    - 6 December 2010

Technical Description

- Marine Corps Warfighting Lab
- Enhanced Maneuver Operations
- Limited Objective Experiment
- Experiment will execute in 2012
- Seeking electrical power solutions for foot mobile units
- Title: "Foot Mobile Charger"
- Announcement: M67854-11-R-9011

ONR Broad Agency Announcement

Office of Naval Research

Solicitation / Procurement

- Issuing Activity:
  - Office of Naval Research
- Initial Issue
  - 24 September 2010 (check for updates)
- Open Through:
  - 30 September 2011

Technical Description

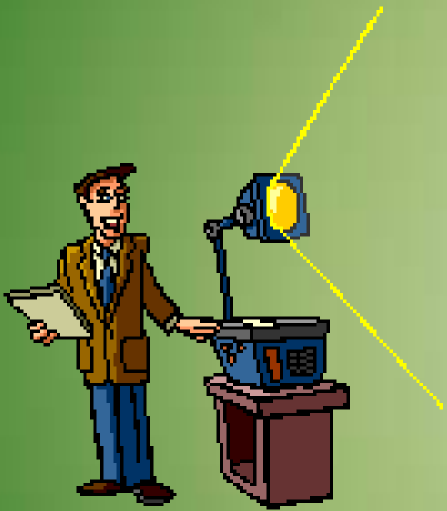
- ONR Announcement # 11-001
- 2011 Long-Range Broad Agency Announcement for Navy and Marine Corps Science and Technology
- http://www.onr.navy.mil/en/Contracts-Grants/Funding-Opportunities/Broad-Agency-Announcements.aspx
- Science & Technology Objectives in the Logistics Thrust Area:
  - Energy scavenging
  - Operational Self Sufficiency
  - Ad-hoc "microgrid" power distribution
  - Simple generator refit kits


Welcome to the
2011 Joint Service Power Exp
"Smaller, Better Greener
Reducing the Energy Footprint

2011 JSPE Steering Committee

- Ken Bensman
- Mike Bissonette
- Don Brockel
- Mike Brundage
- Alden Davidson (NDIA)
- Angie DeKleine (NDIA)
- Nick Foundas
- Marc Gietter
- Lester Gordy
- Justin Govar
- Traci Grantham
- Luellen Hoffman (NDIA)
- Matthew Huffman
- Matt Hutchens
- Capt. Bruce Roulstone (ret) (NDIA)
- Sue Waggoner
- Joanne Martin (member emeritus)

ers



The 2011 Expo would like to say thanks and express our gratitude to….

Our Presenters

Our Support Staff

EXHIBITORS SPONSORS

PARTICPANTS

WE HAVE DISABLED ALL CELL PHONE DEVICES USING OUR LOW POWER DISRUPTER BEAM.

PLEASE CHECK YOUR DEVICE NOW AND...

A RINGING CELL PHONE/ BLACKBERRY IS VERY ANNOYING (AND EMBARRASSING) SO…

Turn them off or set them on Vibrate

Power Source Feedback Group

- Aimed at gaining feedback from real life users
- Secure, can be accessed by DoD CAC holders only
- Share with Warfighter POCs
- http://go.usa.gov/b1S
- Feedback will be provided to the appropriate persons
- Every posting will be answered

Administrative Stuff

- Please wear you badge at all times – our disrupter beam can be easily turned into a death ray
- If you have a question – please contact a member of the Steering Committee or NDIA Staff.
- Copies of the presentations will be available at the NDIA website
- Please limit any presentation to 20 minutes, our session chairs are trained in take down techniques.
- Be prompt – we WILL make fun of anyone who arrives to a session late
- Presenters – please check with the NDIA personnel to make sure your presentation is loaded (and works) on the computers

Last Minute Changes

- "Advancing Renewable Energy Technology Commercialization through Federal, State and Local Collaborations" is now in Session 4
- Lunches are in Ballroom E
- Breakout sessions scheduled for Ballroom E are now in Ballroom ABC

<u>*Disclaimer*</u>

Presentations or exhibits by industry do not constitute an endorsement of the company or product by the Government.

Network Social

- Busses leave from the convention center
- Event runs from
- Two free drinks included
- It is advised that you not walk back to the hotel

Please Remember….

- To visit the Exhibit Area and talk to the exhibitors
- To ASK QUESTIONS – This is an interactive forum
- To join the NDIA Power Forum (membership is free) which has a meeting Thursday afternoon

PLEASE ENJOY THE EXPO!

Lockheed Martin Tactical Power Systems Summary

May 2011

LOCKHEED MARTIN

Bill Heisey
Director Programs & Technology
Electronic Systems
301-897-6433
william.k.heisey@lmco.com

Lockheed Martin Organization

LOCKHEED MARTIN

- Electronic Systems

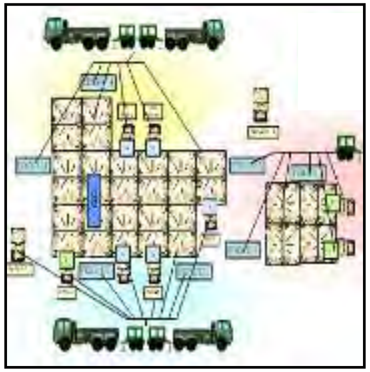
- Aeronautics

- Information Systems and Global Solutions

- Space Systems

Lockheed Martin and Energy

DoD Land Forces Power Issues



Inefficient Architecture

Fuel Convoys

Route Clearance

Hazardous Infrastructure

- War Fighter unnecessarily exposed to convoy and infrastructure hazards
- High O&M costs (fuel, batteries, repairs) due to inefficient use of resources
- Power gaps exist away from generators, vehicles, and wall plugs
- War Fighter burdened with weight in carrying batteries

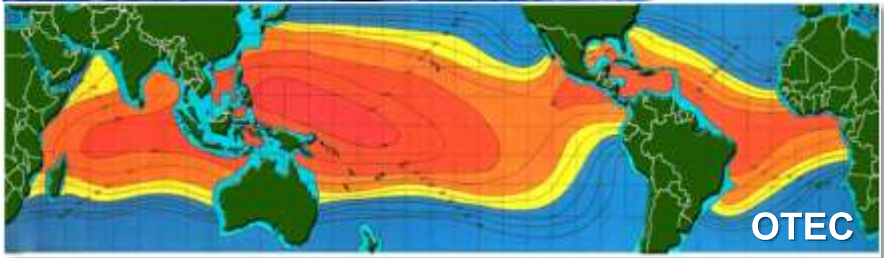
Vehicle Power System Growth

War Fighter Burden

Challenges & Impact of Power are Significant

LM Power Generation & Management

- Ocean Thermal Energy Conversion (OTEC)
- Fuel Cells
- Microgrid
- Mobile Waste to Energy Conversion (MWEC)



Microgrid

LM General R & D Pipeline

Research by Others
Basic research

- DoD SBIR / STTR: $1.5B annually
  - Key source of innovation
- NSF: $6.5B annually (+$3B in FY09 from ARRA)
  - 74% went to universities & consortia
- National Labs

IR&D
Engine that drives our R&D

- Developing innovative and discriminating technologies
- Integrating LM and other's technology to solve customer's problems
- LM labs (ADP, ATL, ATC, CFI)

CR&D
Maturation & Transition focus

- Key to bridging the "valley of death"
- Key to shaping new business & future RFPs
- Reinforces our technology development

Products, Programs

TRL & MRL

Innovation is Key to the Long Term Success of LM

Microgrids R&D Pipeline

Univ, Small Business

- University (Texas A&M, UT Austin, Drexel, etc.)
- Small Business Partnerships (Ideal Power Converters, Skybuilt Power, others)

IR&D

- Microgrid Architecture and algorithm IRAD
- Cohesive LM Energy Systems via MFC Microgrid Architecture
- Hardware/software in the loop intelligent Microgrid Development Center

CR&D

- Hi-Power - AC/DC Trade Study 2008
- Army CERDEC HI-Power 2009/ 2010 – Demo microgrid for Army TOC/FOB
- Air Force Integrated Smart BEAR Power Systems 2010
- ESTCP Ft. Bliss microgrid demo

DoD Tactical /Installation Microgrids, Global Commercial Microgrids

Leveraging University and Small Businesses to Fill Key Gaps

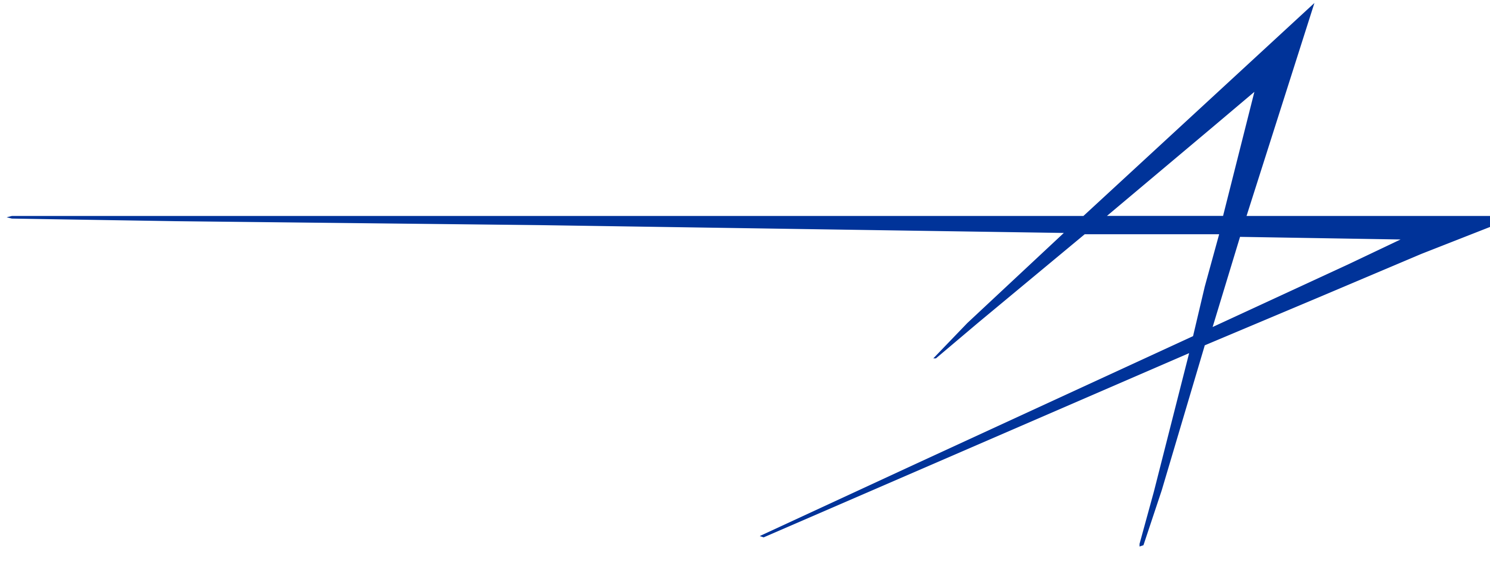
Partnership with Lockheed Martin

- **Mechanisms**
  - Direct Research and Development Contracts (IRAD)
  - Subcontracts from Customer Research and Development (CRAD)
  - Subcontracts from Programs
  - Small Business Innovation Research (SBIR)
  - Direct Response to Broad Area Announcements (BAA)
  - University Research Contract
  - Mentor-Protégé
- **Hot Topics**
  - Intellectual Property
  - Publications

LM Vision and Values

Powered by Innovation, Guided by Integrity, We Help Our Customers Achieve Their Most Challenging Goals

- Do What's Right
- Respect Others
- Perform With Excellence



Lightening the Load:
Defining the Path Forward

3 May 2011

MAJ Steve Meredith
Asst. TCM-Soldier
Soldier Power and Sustainment Team
steven.meredith@us.army.mil

Agenda

- Scope the Problem
- Operational Requirements
- Priorities of Effort
- Gaps
- Gap / Solution Crosswalk

Enhancing the Now

FUTURE

NOW

Tier 1 (Most Austere)

Dismounted Operations in Complex, Restrictive Terrain. Greatest risk acceptance.

Example: Forced Entry Operations in urban, mountain, or jungle terrain. Airborne and Air Assault operations. Search and Attack.

- Intel (receive/transmit)
- Improved (Decentralized) C2
- Linkage to Enablers
- Reduced Burden
- Austere Sustainment (Power)

Tier 1 (Most Austere)

Dismounted Operations in Complex, Restrictive Terrain. Greatest risk acceptance.

Example: Forced Entry Operations in urban, mountain, or jungle terrain. Airborne and Air Assault operations. Search and Attack.

- 500 Meter Radio
- Dated Intelligence
- Loss of Vision
- Battle Drills
- Convoluted Clearance
- Tactics

Tier 2

Operations with Armored, Mechanized, or Wheeled Forces.

Example: Airland Vehicles, Heavy LZ, Convoy Link-up. Company FOBs in OEF.

- Multiple Communications Modes
- Enhanced Medical
- Resupply
- CAT Teams
- Power
- Sensors

Tier 3 (Most Robust)

Operations from Secure Forward Operating Base (FOB).

Example: Well established presence and long term occupation. Additional COTs with contractors to sustain them.

- Intelligence
- Attack Aviation
- Fires
- Power
- Morale
- Services
- Sensors

Problem

The sharp rise in Soldier worn capability has resulted in a dramatic increase in the numbers, and variety of batteries carried by the Warfighter. This trend is unsustainable from a Soldier load and logistical perspective.

Symptoms:

- Trade-offs for power in way of mobility, lethality, and agility
- Decreased Unit/Soldier range and endurance - limits mission duration & engagement time
- Increased fatigue (increased energy expenditure results in carrying more water and food)
- Overly frequent halts in operations to swap batteries
- Excessive sustainment footprint
- Cost:
  – Lives
  – Medical
  – Procurement (Military specific applications & cost for new battery R&D)
  – O&M (sole-source batteries)
  – Transportation (compounds with distance)

Causes:

- ***Soldier Load (volume, weight and configuration which limit mobility)***
- Dramatic increase in power and energy for Soldier support equipment
- Battery proliferation (too many types, voltages, power)
- No effective means to generate power in an austere environment
- Lack of Soldier confidence in battery state of charge

Problem to Impact

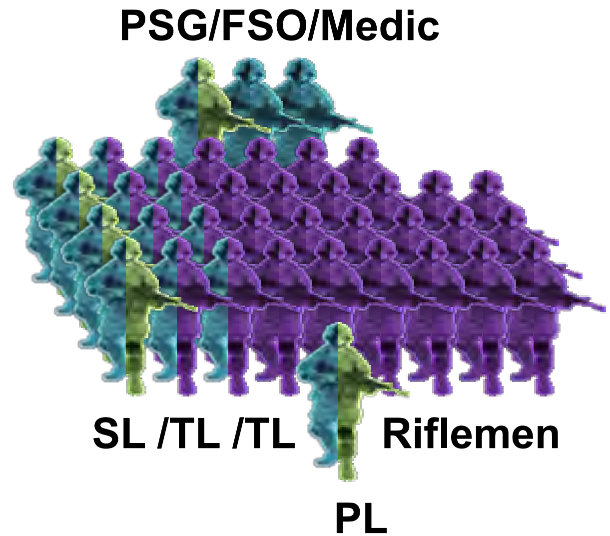
Problem	Contributing Factors	Corrective Action
Soldier Load	Water	No direct fixes
	Food	No direct fixes
	Power / Batteries	Next generation family of batteries
		Small unit power generation / recharging
		Reduced system power demand
		Power monitoring and management
	Ammo	Lightweight Small Caliber Ammunition (20% reduction)
	Body Armor	Soldier Protection System (10-15% reduction)
	Medical	No significant direct fixes

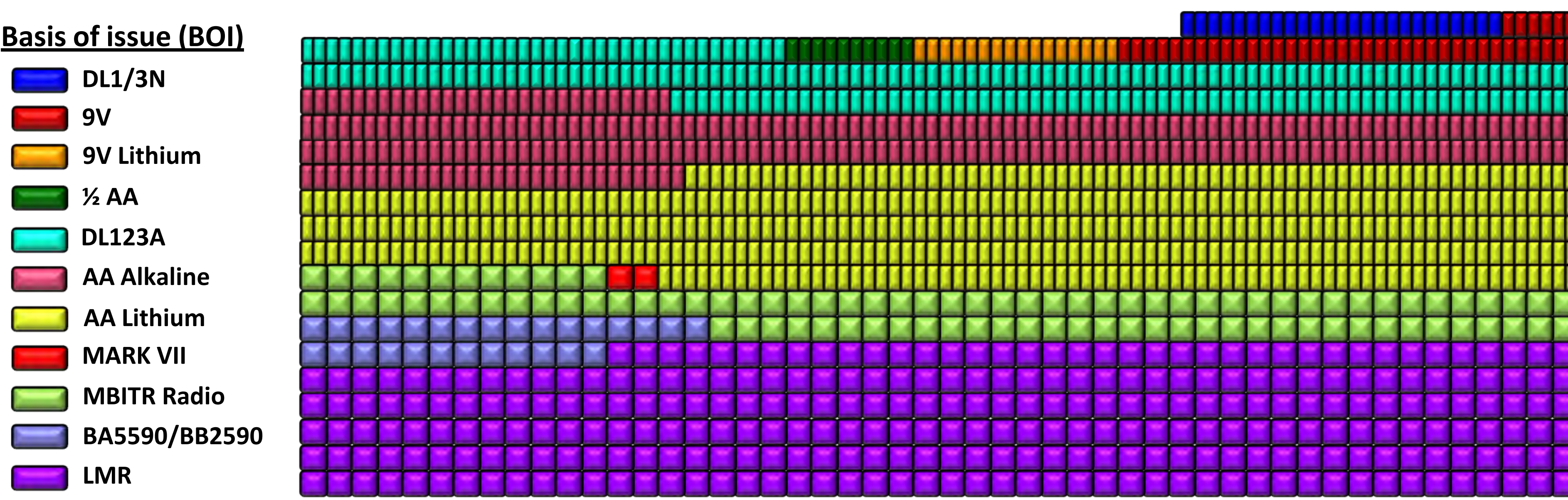
Walking the Dog: Problem to Impact

Contributing Factors	Corrective Action	Benefit 1st order	Benefit 2d order
Water	No direct fixes	Trade Space for Additional food/water	Small Unit agile and flexible to remain in contact with enemy/people.
Food	No direct fixes		
Power / Batteries	Next generation family of batteries	Reduced Weight Same or Increased Power Inherent Base Power Power Generation	
	Small unit power generation / recharging		
	Reduced system power demand		
	Power monitoring and management		
Ammo	Lightweight Small Caliber Ammunition (20% reduction)	Trade Space for Additional CL V/FP/MED or PLT EQUIP	
Body Armor	Soldier Protection System (10-15% reduction)		
Medical	No significant direct fixes		

2010 Infantry Rifle Platoon 72 Mission Hour Requirement

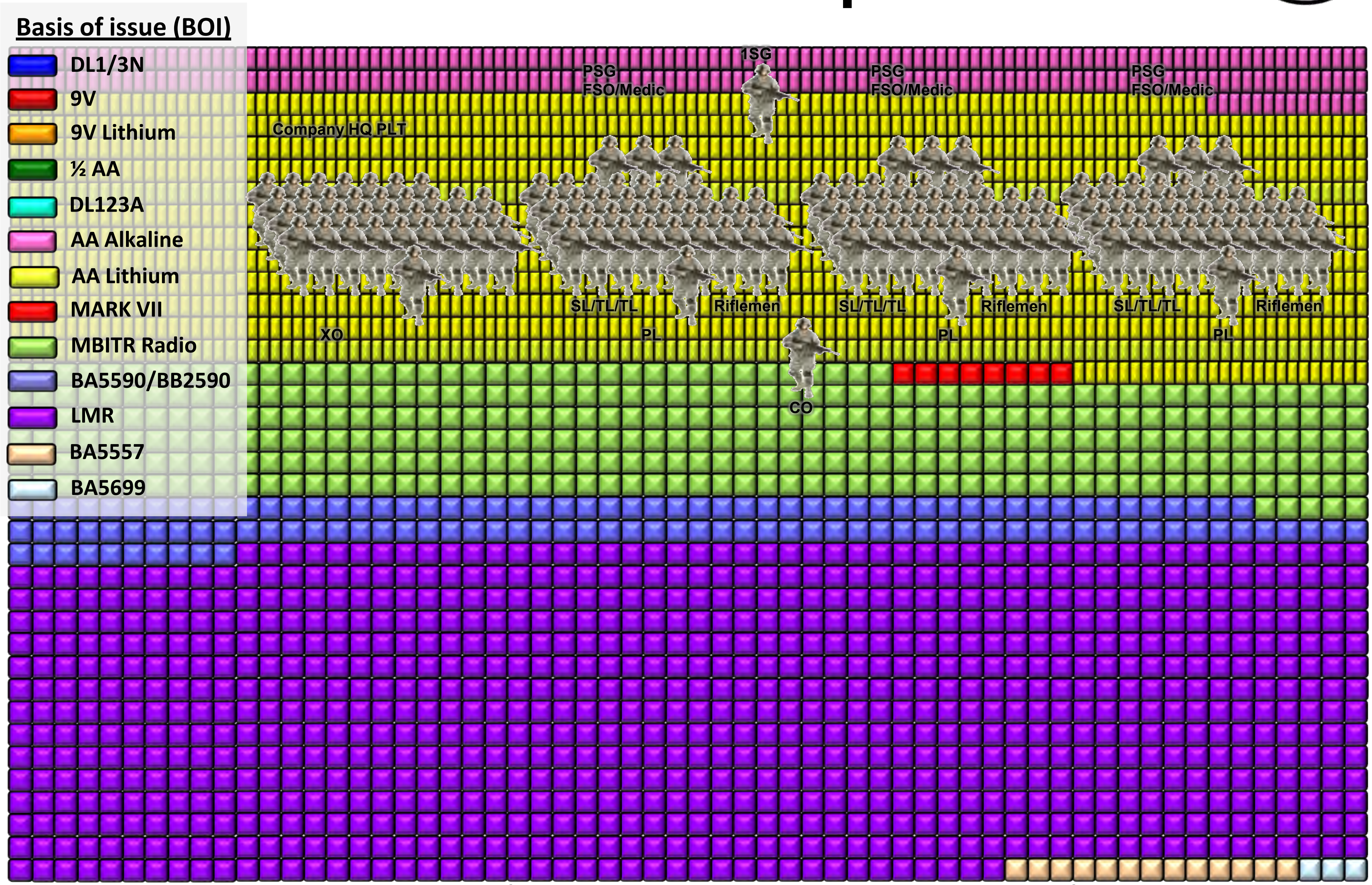
11 Battery Types, 1418 Batteries, Per Platoon, 412-436 LBS for a 72 Hour Mission





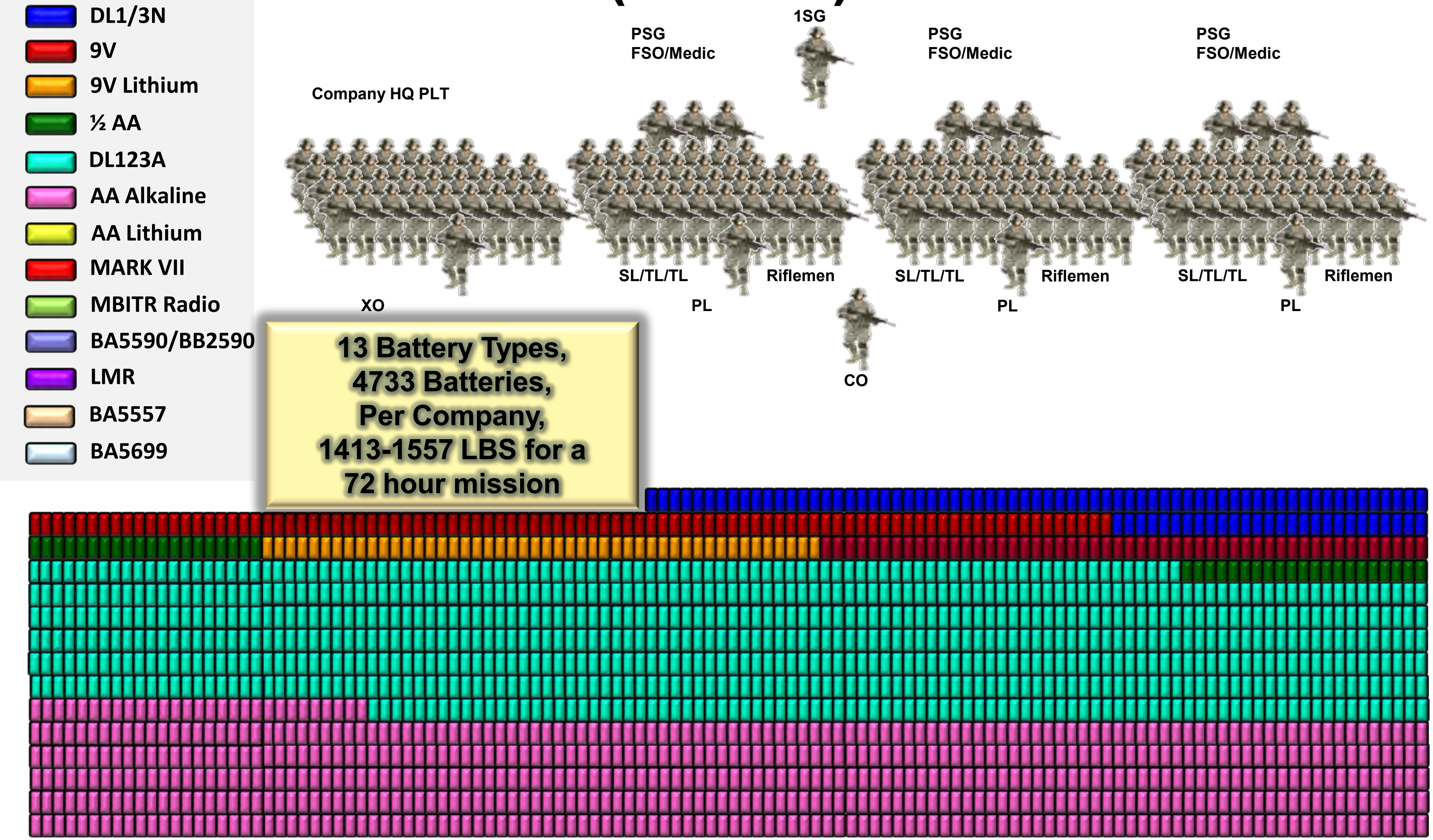
Based on 2010 CERDEC/MCOE analysis; assumes BOI systems are carried/worn

2010 Infantry Rifle Company
72 Mission Hour Requirement



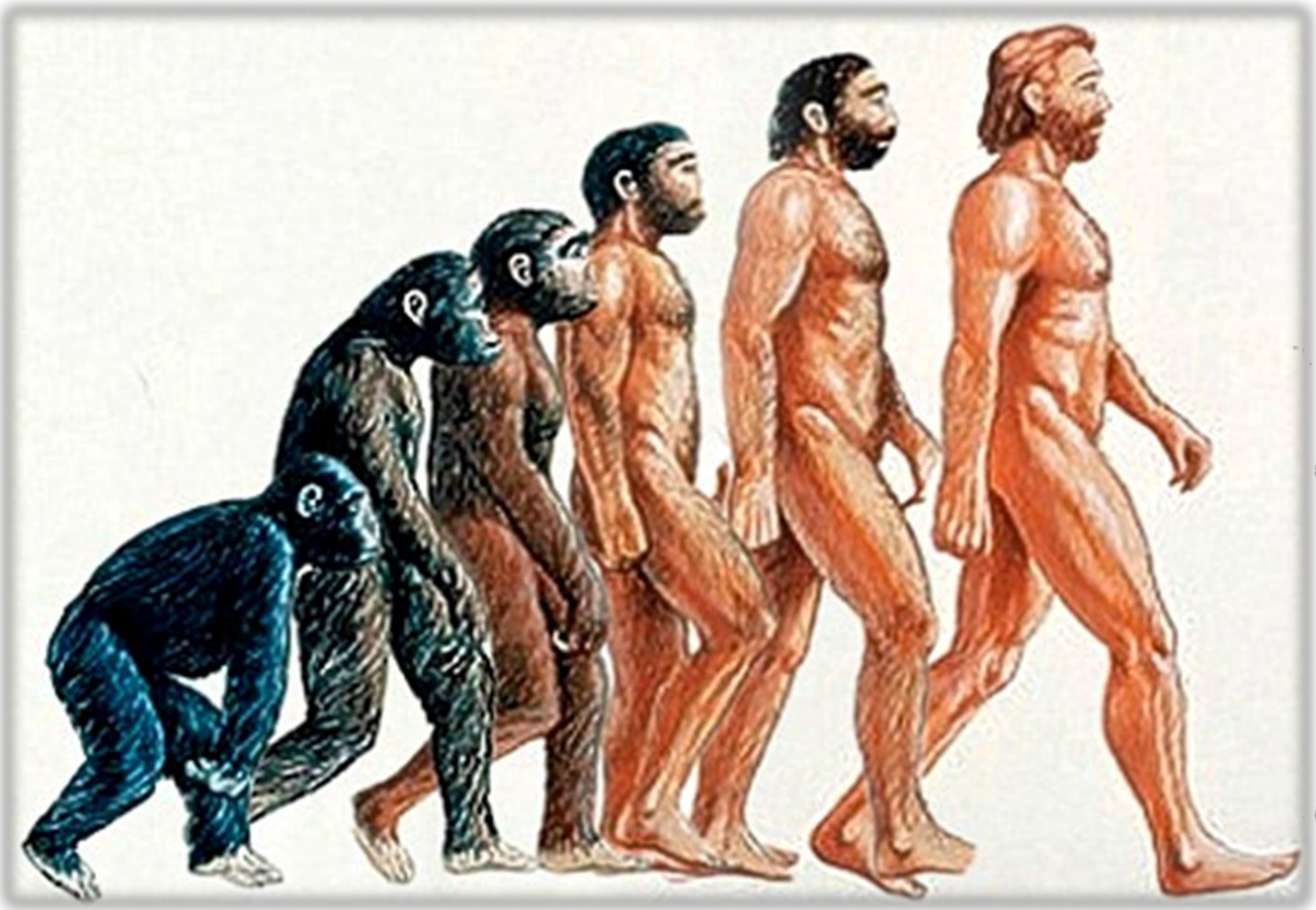
Based on 2010 CERDEC/MCOE analysis; assumes BOI systems are carried/worn

2010 Infantry Rifle Company 72 Mission Hour Requirement (Cont'd)



Based on 2010 CERDEC/MCOE analysis; assumes BOI systems are carried/worn

How did we go back in time?



WEIGHT

MCoE Soldier Priorities of Effort

- Develop Strategy, Plan, Metrics, Objectives
- Define Efforts
- Determine and Document Requirements
- Establish MCoE Soldier Power management construct
- Determine Funding Requirements
- Guide Policy and Regulatory Guidance
- Implement Solutions

Operational Energy ICD Gaps

1	Power source duration
2	Energy management processes
3	High efficiency energy conversion & distribution systems
4	Common power source for Soldier Systems
5	Energy demand
6	Energy interoperable interfaces
7	Widely dispersed power generation
8	Engagement systems
9	Petroleum energy systems
10	Tactical energy conversion and distribution
11	Institutional Energy Awareness
12	Single fuel standard
13	Refueling and rearming operations
14	Bulk fuel, liquid storage and distribution systems
15	Alternative energy sources
16	Interoperability with non-US military systems

Note: Operational Energy ICD signed by LTG Vane, 31 JAN 2011; currently in Army staffing

Grayed areas apply more to platform, base camp, or aviation

Army ↔ USMC Comparison

Army Gaps	
1	Power source duration (Soldier, aerial platforms, ground systems)
2	Energy management processes
3	High efficiency energy conversion & distribution systems
4	Common power source for Soldier Systems
5	Energy demand
6	Energy interoperable interfaces
7	Widely dispersed power generation
8	Engagement systems
9	Petroleum energy systems
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16	Interoperability with non-US military systems

Note: Operational Energy ICD signed by LTG Vane, 31 JAN 2011; currently in Army staffing

USMC Tasks	
1	Plan to supply Energy (conventional, renewable, alternative) to the MAGTF; integrated throughout the supply chain and with Joint/Coalition and HNS
2	Provide the capability to Manage Energy, Water, and Waste Resources in an Expeditionary Environment
3	Conduct Combat Operations across the MAGTF with minimal energy and energy related logistics requirements
4	Plan for reductions in energy demands of current and future capability sets without reducing combat/mission effectiveness
6	Plan and Design Efficient, Scalable Expeditionary Forward Operating Base Utilities
7	Provide the capability to Measure Energy, Water, and Waste Resources in an Expeditionary Environment
8	Conduct "smart" expeditionary Electrical Distribution
9	Plan to produce all C4I energy and power requirements organically in place
12	Conduct Expeditionary Bulk Fuel Distribution
13	Provide a Power Source appropriate to the individual user's required capability
14	Provide the capability to Analyze data on Energy, Water, and Waste Resources in an expeditionary environment
15	Produce Energy Efficient Climate Control environments to maintain Personnel and Equipment operating efficiency
19	Develop migration plan for FOB to transition from expeditionary to enduring base
23	Management of additional tasks to comply with higher guidance (i.e. DoDI regarding burn pits, etc.) in an expeditionary environment
24	Provide Storage for Collection of Energy Sources Other than Liquid Fuels

Note: Info from draft Expeditionary Energy, Water and Waste (E2W2) ICD

Grayed areas apply more to platform, base camp, or aviation

Potential DOTMLPF Solutions

Doctrine (and Policy):
- Resupply operations / methods
- Policy/Regulation: Energy Efficiency must be mandatory
- CECOM "Preferred Battery List" must be updated and enforced

Organization:
- MCoE named Proponent for Soldier Power
- Establish MCoE Soldier Power Branch
- Establish PD Battery (PM MEP, PEO C3T)
- Assess MTOE basis of issue
- Modify MTOEs to retire / reallocate systems not being utilized

Training:
- Power conservation must be instilled in Soldiers from day one
- Power monitoring and management

Leadership and Education:
- Educate leaders on importance of conservation and extending life of all systems
- Provide feedback to leaders on power consumption after deployments

Personnel: TBD

Facilities: TBD

Materiel:
- Personal, Squad, and Platoon recharging and distribution capability
- New standard family of batteries (cyclical upgrades)
  - increased power, energy density, and configurations
- Standardized power interface/connectors
- Soldier/unit level power monitoring and management
- Future systems must be "smart"
  - Automatic power monitoring and management with manual override
  - Reduced system energy demand
- Standard family of alternative energy sources (fuel cells)
- Vehicles must have SWaP allocated for rechargers
- Wireless power distro → one power source becomes reality

Soldier Load

Cause	Corrective Action (Proposed)
Soldier Load (volume, weight and configuration which limit mobility)	•Establish MCoE Soldier Power management construct •Establish PD Battery •Education and training Modify MTOEs to retire / reallocate systems not being utilized
Dramatic increase in power and energy for Soldier equipment	•Energy efficiency KPPs •Standardize system power draw •Require and enforce policy adherence

Battery proliferation (too many types, voltages, power)	•Update CECOM “preferred” battery list
	  •Time phased reduction in types
	  •Establish enforcement committee/proponent
	•New family of batteries w/ cyclical upgrades
	•Develop standard interfaces / connectors

No effective means to recharge in an austere environment	•Small unit power generation / recharging •Standard family of alternative energy sources •Platforms must have SWaP allocated for rechargers
Lack of Soldier confidence in battery state of charge	•Power monitoring and management

Proposed Incremental Approach

Fort Benning, Home of the MCoE

2011 — 2015 — 2020

Inc 1 (2011-2015)

- New Family of Batteries
  - Adds Conformal and Clam Shell
- Battery Type Reduction
- Squad Recharging (RFI or SEP)
- Platoon Generators (RFI or SEP)
- Energy Efficient Systems
- Acquisition & Policy Reform
- Conservation & Efficiency Training & Education

Inc 2 (2016-2020)

- New Family of Batteries (Next Gen)
- Further Battery Type Reduction
- Energy Efficient Systems
- Individual Soldier Recharging
- Soldier Power Monitor / Management

Inc 3 (2021-2030)

- Wireless Recharging and Power
- Integrated Power

Soldier Power WG est. DEC 2010

Message…

- To Government partners
  - Requirements development
  - Collaboration
  - Common vision
- To industry
  - Industry Standards (battery types and interface)
  - Industry day
  - Demonstrations, competitions, “shoot offs”
- To academia
  - Partner with CERDEC and NSRDEC

Questions???

U.S. Army Research, Development and Engineering Command

OVERVIEW: CERDEC Quick Reaction Cell / Warfighter Support Office

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Overview

Troy Steward

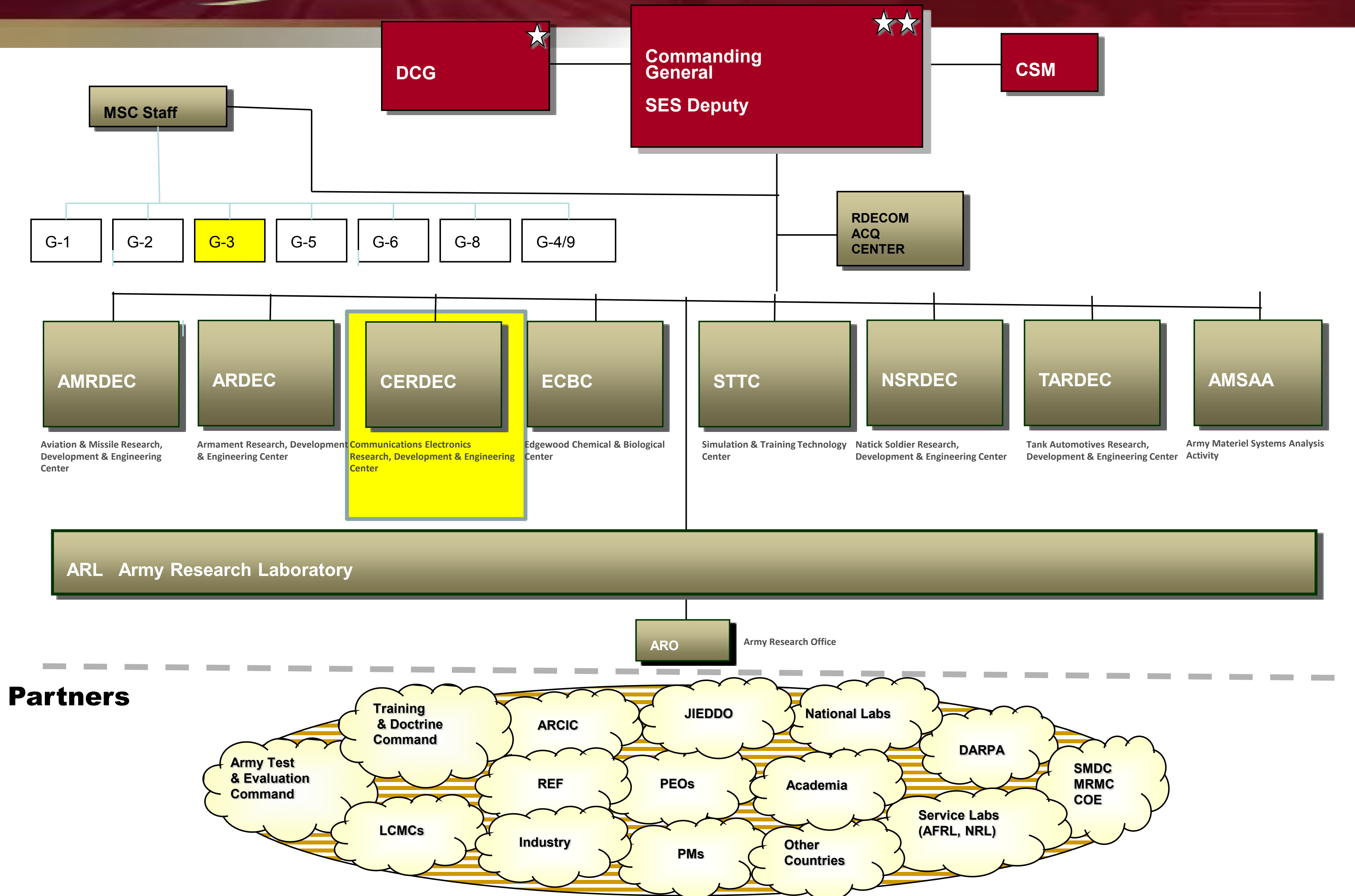
Combat Developer- Warfighter Support Office

Cell: 732-281-7531

NIPR: william.t.steward@us.army.mil

SIPR: william.t.steward@us.army.smil.mil

RDECOM Organization



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

CERDEC Organization
Where the QRC fits in

US ARMY RDECOM

CERDEC US ARMY – RDECOM

OFFICE OF THE DIRECTOR

Director – Ms Jill Smith *(SES)*
Associate Director – *Robert Zanzalari*
Military Deputy – *COL Surdu*
Chief Scientist – *Dr. Arthur Ballato*

Chief Information Office/G6
Theresa Bickler

Security/G2
Vicki Soos

HQ STAFF

Associate Director For Transformation
Michael Lombardi

Associate Director For Systems Engineering
Seyhun Byrne (A)

PdM C4ISR OTM
LTC Willie Utroska

Associate Director Operations
Thomas O'Neill

Current Operations/Quick Reaction Cell
Joseph Johnson

Associate Director Technology & Strategic Planning
Mari Kovach

DIRECTORATES

Command& Control (C2D)
John Soos (Acting)
Director

- Battle Command
- Army Power
- Battle Command Appl
- Quick Reaction & Battle Command Support

Space & Terrestrial Communications (S&TCD)
Henry Muller *(SES)*
Director

- Systems Engineering Analysis & Modeling and Simulation (SEAMS)
- Information Assurance
- SATCOM
- Antennas & Spectrum Analysis
- Tactical Wireless Networking
- GIG Tactical Networks

Night Vision & Electronic Sensors (NV&ESD)
A. Fenner Milton *(SES)*
Director

- Science and Technology
- Countermine
- Modeling and Simulation
- Ground Combat Systems
- Special Projects & Prototyping
- Air Systems

Intelligence & Information Warfare (I2WD)
Anthony Lisuzzo *(SES)*
Director

- Information Operations
- Electronic Warfare
- Air / Ground Survivability
- Fusion
- RADAR
- SIGINT

Software Engineering (SED)
Michael Skurla
Director

- IEW Support
- Avionics Support
- Tactical Communications
- Satellite & Management Sys
- Information Technology Engr
- Advanced Battlespace Solutions
- Fire Support

Product Realization (PRD)
Ron Michel
Director

- Manufacturing systems & production engineering
- Maintenance & reliability engineering
- Systems engineering
- Manufacturing assessments
- Supply network analysis

= Fort Monmouth
= APG
= Fort Belvoir

CERDEC Quick Reaction Cell Organization

CERDEC
Office of the Director

CERDEC MILDEP
COL SURDU

Director – Current Operations
QRC
Joe Johnson

Combat Developer
Troy Steward (Kr)

Warfighter Support
Office (WSO)

QRC
System Engineer /
Deputy Director
Gregg Hennessy

QRC
Program Analyst
Brent Christensen

QRC
RFI/Tasker Analyst

Mike Watts

CERDEC
I2WD

CERDEC
NVESD

CERDEC
STCD

CERDEC
C2

WHY?

Mission: Support the current fight through providing technical & warfighter expertise to bridge the gap between the RD&E community & the Warfighter

Ultimately facilitate the employment of prototypical material solutions to meet the Combatant Commanders requirements

Quick Reaction Cell/Warfighter Support Office

WHAT

What We Do:

- Act as CERDEC "Front Door" for providing Warfighter **C4ISR Quick Reaction Capability**
- Assist CERDEC Technical Directorates in obtaining and interpreting **Soldier Feedback**
- Feed and **Interpret Near Term Warfighter Requirements** to the Directorates by
  - Assist in cross collaboration in the world of C4ISR (PEO's/PM's), to include down to the BCT level
  - **Rapidly respond to Requests for Information** (RFI's) from the field (to include BCTs and Battalions)
- Provide leadership and guidance to CERDEC Directorates to include advising Directorates on existing ONS/JUONS that fit within their portfolios
- Advise CERDEC Directorates on **current tactics, trends and threats for future development**
- Maintain working groups with all COCOMs and associated entities, JIEDDO, and OGAs.
- **Coordination and liaison with sister RDEC's across RDECOM**

Rucksack Enhanced Portable Power System (REPPS)

Benefits:

- Provides device power or battery recharging capability from Solar, AC, Military Batteries, NATO plug, and Cigarette adapter.

Uses:

- Recharges BB2590 and MBITR batteries
- Provides continuous power for unattended ground sensors (UGS) and surveillance cameras.
- Powers laptops
- Powers any device that uses a BA5590 battery

QRC Involvement :

- Helped issue hundreds of kits to National Guard and Active Units both CONUS and OCONUS
- Facilitated feedback gathering from units back to C2D-Power
- Identify needs via our continuing working involvement with units to validate those with the greatest need.

Request for Information

Project Title/Subject:	Soldier Portable Photovoltaic Solar Panel Power for Continuous Charging of Vector Surveillance Light Traps
Originator:	LTC Sonya Schleich/MAJ Joseph Fagan
Issue Date:	12/22/2009
Reply By Date:	1/11/2009
Email:	Sonya.schleich@iraq.centcom.mil; joseph.fagan@mmcs.army.mil
Phone:	DSN (312) 987-5130, 1, x 3502#
Status:	Open - Awaiting Response from Lab

Issue/Summary:

UNIT REQUESTED: Applicable to all Preventive Medicine Detachments (227th Medical Detachment, PM)

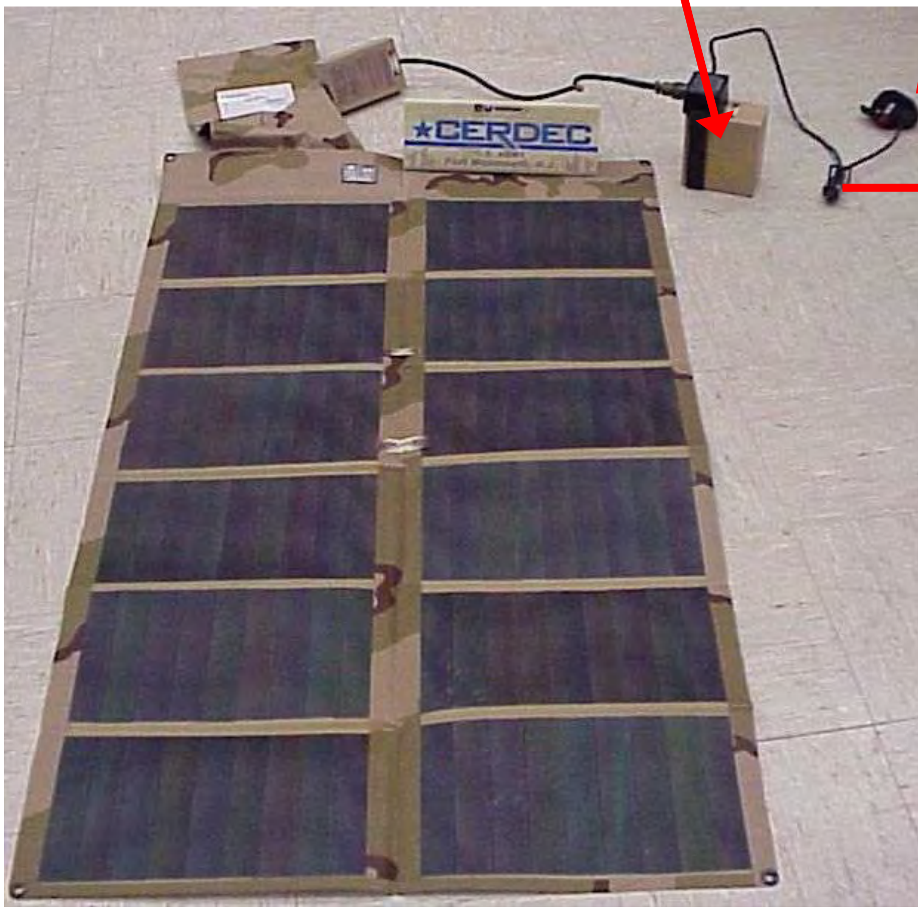
Background: Preventive Medicine Detachments are required by AR 40-5 to perform disease vector surveillance and assess circulating pathogens, i.e., those that cause malaria, leishmaniasis. The piece of equipment utilized to perform this activity is part of the MES, UA 124A, Entomological Collecting Kit, Field. The item is commonly known as the CDC Light Trap, model 512. Each trap is operated using a rechargeable 6 V gel cell battery. Traps are operated anywhere from 3 to 7 days per week at several sites per week for continual surveillance. Operation of these traps requires placement between a vector breeding area and troop population. These locations are usually spread over great distances for each location under surveillance. Traps generally operate for 8 hours and are programmable to turn on and off using a photo cell sensor. The light trap utilizes a power source to operate a fan and light (when applicable). The current power source is a 6.0-6.3 volt DC 12-Amp hour, 320mAmps (0.320 Amps) / hour (NSN 6140-00-432-0490). Light Trap NSN 3740-01-106-0091

Performance Gap: The 6V battery must be replaced after 8 hours of usage. This requires a daily trip to each trap in order to change out the spent battery. Personnel must transport the spent battery back to the unit area in order to hook it up to a recharging station. This requires the use of limited manpower and time for a 13 person detachment in which vector surveillance is only part of many preventive medicine force health protection missions.

Replacing 6V Gel Cell w/ BB-2590

BB-2590

12V to 6V Converter



Interface to include adaptor/connector

Sundial slide

Benefits:

- Sundial SmartPowerTM is a reliable, lightweight renewable power solution that can be deployed immediately to remote bases in combat zones, CONUS areas of natural disasters or for global humanitarian missions.
- SmartPowerTM units come in modular 20' containers and can be scaled up to 500 KW to meet local requirements.
- SmartPowerTM units can also be integrated with and manage micro-hydro & diesel power generation units, thereby making a single platform for power distribution.

Uses:

- Provide renewable power to bases, FOBs, or COPs in warzones.
- Can also be used to extend power to the local community near military outposts as a reward for helping US forces.
- Is quickly deployable to areas of mass natural disasters (Hiati, Alabama, etc)

QRC Involvement :

- Established relationship with Sundial Corp early on and started facilitating discussion to CERDEC engineers.
- Tracked progress of system being acquired by US Army Forces for testing/evaluation.
- Monitored testing results of system by CERDEC prior to being deployed to Afghanistan.
- Have maintained contact with CONUS Army Project Manager and OCONUS overseeing manager, and RDECOM advisors in theater.

TES/MILES–Battery issues

Issue:

- New TES/MILES system used at National Training Center (NTC) utilizes standard and non-standard batteries.
- The number of batteries issued every rotation has a very heavy cost.
- NTC needs a method to recharge hundreds, if not thousands of batteries a day in order to re-use batteries during rotation cycles.

Coarse of Action:

- Utilize Existing chargers in the Army's inventory.
- Modify an existing solar recharge system (like REPPS) to push out the power needed to charge multiple batteries at one time out in the field
- Conduct a market search of industry to see if there is any COTS solution available that would handle this battery load or could be easily modified to handle the battery load.

QRC Involvement :

- Visited NTC to conduct face to face meetings in order to understand the problem.
- Work with the CERDEC-C2D power team in order to determine what the Army has available.
- Search industry to see what is potentially available.

TES/MILES BATTERY REPORT

TES SYSTEM EQUIPMENT	DEVICE NUMBER / PT NUMBER	BATTERY REQUIRED	ON HAND	AVERAGE REQUIRED	ISSUED THIS ROTATION	ON ORDER	AWM	REMAINING	NEEDED
Individual Weapon System (SAT)	DVC 23- 67/68/69/70/71	LS 14250 3.6v	69,100	0	8,400	0	N/A	60,700	
		NSN: 6135-01-435-4921 / P/N 08111E125	$2.42 Each						
Individual Weapon System (Harness)	DVC 23-(ALL) P/N 184150-2	CR123A 3.0v	95,520	0	17,240	0	N/A	78,280	
		NSN: 6135-01-351-1131 / P/N B-2017	$19.15 Package of 12						
OH-58 & Stand Alone DCIs (Feulers, Fire markers, Contact Teams)	Instrumentation	BB390 BATTERY	287	0	0	0		287	
		P/N BT-70790							
OSV & MBT	DVC # 23-12 NTC	SCAB BATTERY	176	0	5	0		171	
		Douglas/Guardian DG12-18NB							
Individual Weapon System Overlay	P/N 184385-1	15.6 VDC PB-LW-01 BATT	12,520	50	0	0		12,520	
		P/N PB-LW-01							
OH-58 & SOKAL	AGESS I, DVC 07-65/3A	6 VOLT BATTERY	324	0	14	0	N/A	310	
		NSN: 6135-01-333-6737	$30.92 Package of 6						
MWLD Torso / Helmet	DVC 07-56 P/N 11748856 & 11748893	9 VOLT BATTERY	75,940	0	1,800	0	N/A	74,140	
		NSN: 6135-00-900-2139	$9.85 Package of 12						
MILES Universal Control Device	DVC 17-275	AA BATTERY	0	0	0	0	N/A	0	
		NSN: 6135-00-985-7845 P/N EN91	$5.47 Package of 12						
ITAS TOW		Rechargeable AA	40		0	0	N/A	40	
Wirelless Independent Target System (WITS)	DVC 17-237/A & 17-237/A/1	AA BATT LITH	53,320	0	3,080	0	N/A	50,240	
		NSN: 6135-01-333-6101	$18.19 Package of 12						

12:02 AM 1 OF 1 5/3/11

Quick Reaction Cell/Warfighter Support Office

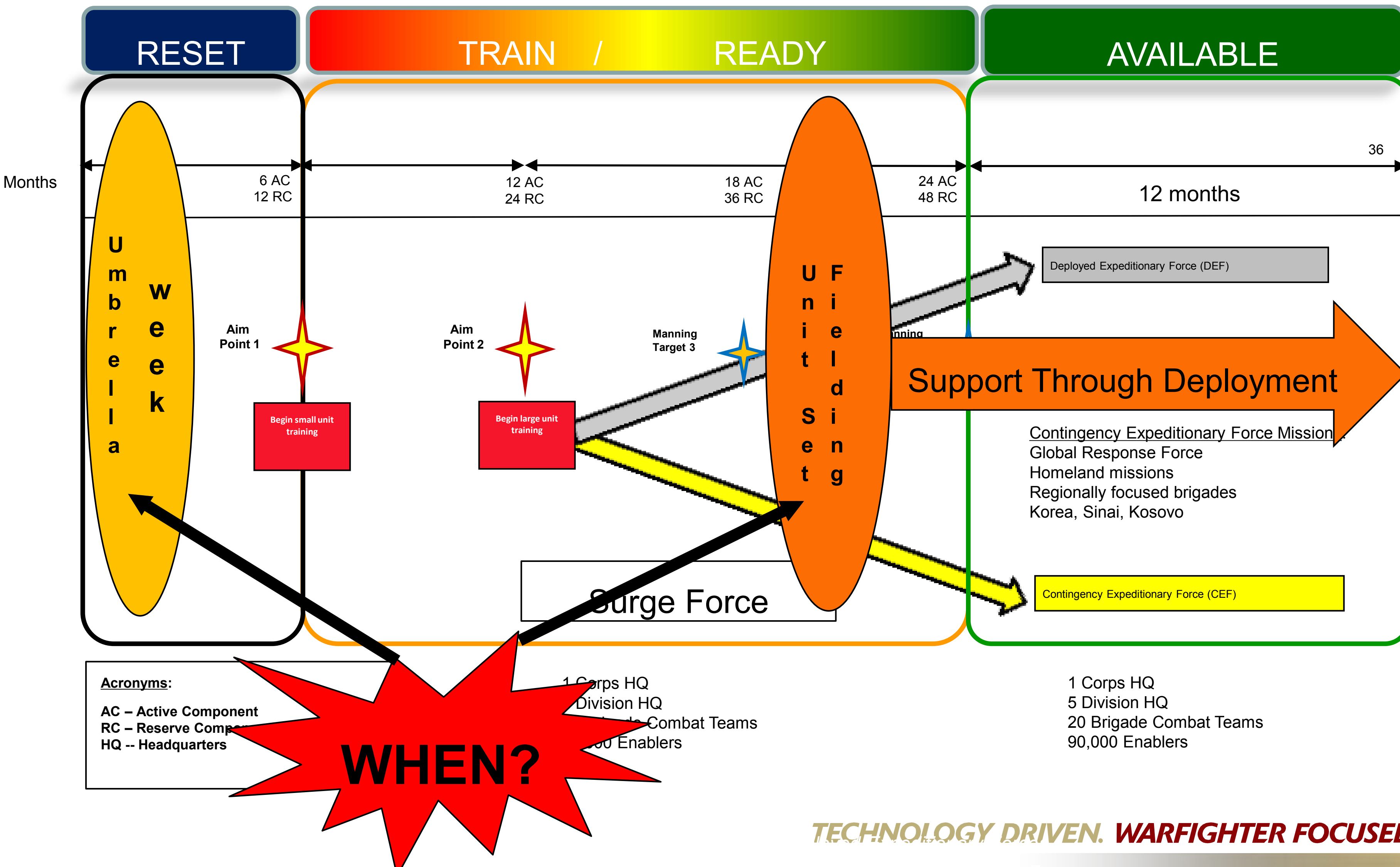
WHO?

HOW?

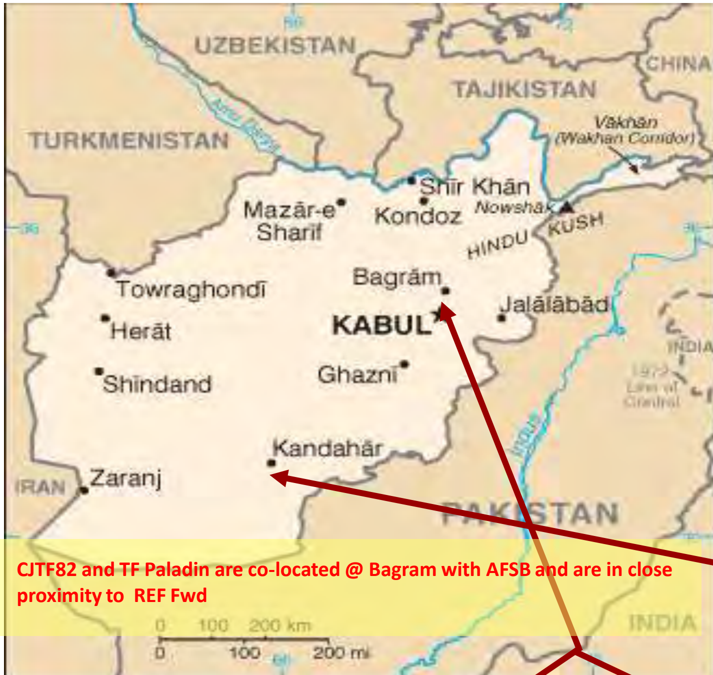
- Responded to 1st Army East's request to provide critical GRRIP training to the deploying 86th IBCT
- Assisted the STCD directorate to test new ECM-Comms mitigation systems in country, by tapping into relationships with 86th IBCT to host CERDEC engineers
- Provided limited distribution of new solar-panel battery charging systems to Special Forces, 4/25th ABCT, 1/4th BCT, 27th IBCT, 86th IBCTand 42nd Division HQ
- Discovered vulnerabilities with sensor systems by reviewing INSUMs from theater and working with the directorate to start working a resolution
- Providing direct assistance to USARAK for real-world OH-58 communication problem and for Joint Base cross-domain information sharing
- Working with JIEDDO's "attack the network" team and elements from USASOC, SOCOM and JSOC on TTL technology development possibilities
- Developed or are developing relationships with 3/10th 2/34th, 37th and 27th IBCTs for their upcoming deployments
- **Established formal relationship with CALL Umbrella Week and PEO-C3T USF process to be part of the ARFORGEN lifecycle**

What is ARFORGEN and how does CERDEC fit?

A versatile mix of tailorable and networked formations operating on a rotational model



RDECOM (Afghanistan)



ON THE GROUND

OBJECTIVE: Support assigned Unit with S&T Advise and facilitate S&T support through operational assessments and reach back to RDECOM network of labs/RDECs

The S&T supports CJTF 82, TF Paladin, and the AFSB. A new S&T Team is going to support RC-South starting with this rotation.

Short list of projects include:

- Fuel Cell
- Improved Cold Weather Gear
- Wide FOV NVG
- Spider / Matrix

CJTF 82 S&T #2 (Sep 09- Mar 10)
Ldr - MAJ Anthony Douglas (ARL)
NCO – SFC Gary Reese (ARL)

TF Paladin (East) #8 (Sep 09- Mar 10)
Ldr LTC Keith Harvey (ARL)
NCOIC MSG Carl Flowers (ARDEC)

RC-South #1(Sep 09- Mar 10)
Ldr - MAJ Jared Novak (TARDEC)
NCO – SFC Jimmie Smith (ARL)
MAJ Victor Melendez (MRMC)

CJTF 82 S&T #3 (Feb - Aug10)
Ldr - LTC Victor Nakano (TARDEC)
NCO – MSG James Laferty (AMRDEC)

TF Paladin (East) # 9 (Mar – Sep 10)
Ldr LTC Thomas Kelley (AMRDEC)
NCOIC SSG Joshua Johnston (ARDEC)

RC-South #2(Sep 09- Mar 10)
Ldr - MAJ Brian Souhan (ARDEC)
NCO – SFC Jimmie Smith (ARL)
MAJ Robert Carter (MRMC)

Points of Contact

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william.t.steward@us.army.mil

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george.m.watts@us.army.mil

Battery Management for Monitoring up to Six Lead-Acid Batteries at the Individual Battery and System Levels

Dr. David Liu, PhD

NDIA Joint Service Power Expo

May 3, 2011

Overview

- Why Do We Need a Battery Fuel Gauge?
- Capabilities and Benefits of HDM BFG Technology
- BFG Application Examples
- BFG Configurations
- HDM's BFG Dual Tracking Methodology
- BFG Highlights Effects of Unhealthy Batteries on the Bank
- Re-Cap

Information is Power

You would not drive a car without a gas gauge…

Why would you execute a mission-critical operation, such as "silent watch", without a Battery Fuel Gauge?

Capabilities of HDM BFG Technology

- Battery Power Usage Information: Diagnostics and Prognostics
  - **State of Charge (SOC) at 95% Accuracy**
  - **State of Health (SOH) at 95% Accuracy**
  - **Hours Remaining (HR) at 90% Accuracy**
  - Battery Voltage (V)
  - Battery Temperature (T)
  - Current (I)
  - State of Life (SOL)
- Functionality
  - System Interface: CANBUS, RS232, Control Panel-Mounted Display
  - Real-Time Data and Estimations
  - Self-Calibration
  - Lightweight Packaging

Benefits of HDM BFG Technology

- Operations
  - Alerts crew when re-charging is necessary
  - Provides Hours Remaining for silent watch
  - Ensures mission capacity and success
- Maintenance
  - Identifies unhealthy batteries for replacement
  - Facilitates Condition-Based Maintenance (CBM)
- Cost-Efficiency
  - Single BFG per system vs. multiple BFGs per system
  - Simple configuration reduces install, operation, and maintenance
  - Powerful tool for intelligent power management systems

BFG Implementation Mobile Application

- Customer
  - Navistar Defense
    - UK MOD/NATO
- Vehicle
  - Husky Tactical Support Vehicle
- Application
  - Monitors Battery SOC and SOH

Over 1500 HDM BFGs have been installed in Husky TSVs in Afghanistan supporting the NATO troops

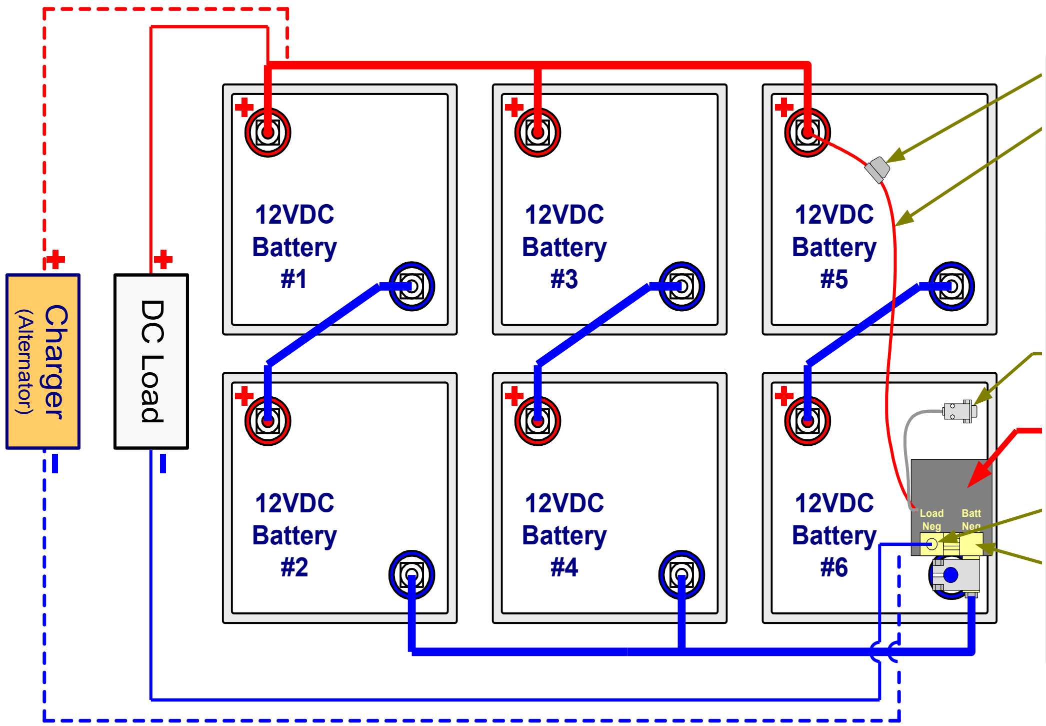
BFG Implementation Stationary Application

- Customer
  - Raytheon Company
- System
  - R-Series Regenerator Hybrid Power System
- Application
  - USMC Experimental Forward Operating Base Phase IV Demonstration in 2010 at 29 Palms, CA

HDM BFG is critical component of intelligent Hybrid Power System

Battery Fuel Gauge Configurations

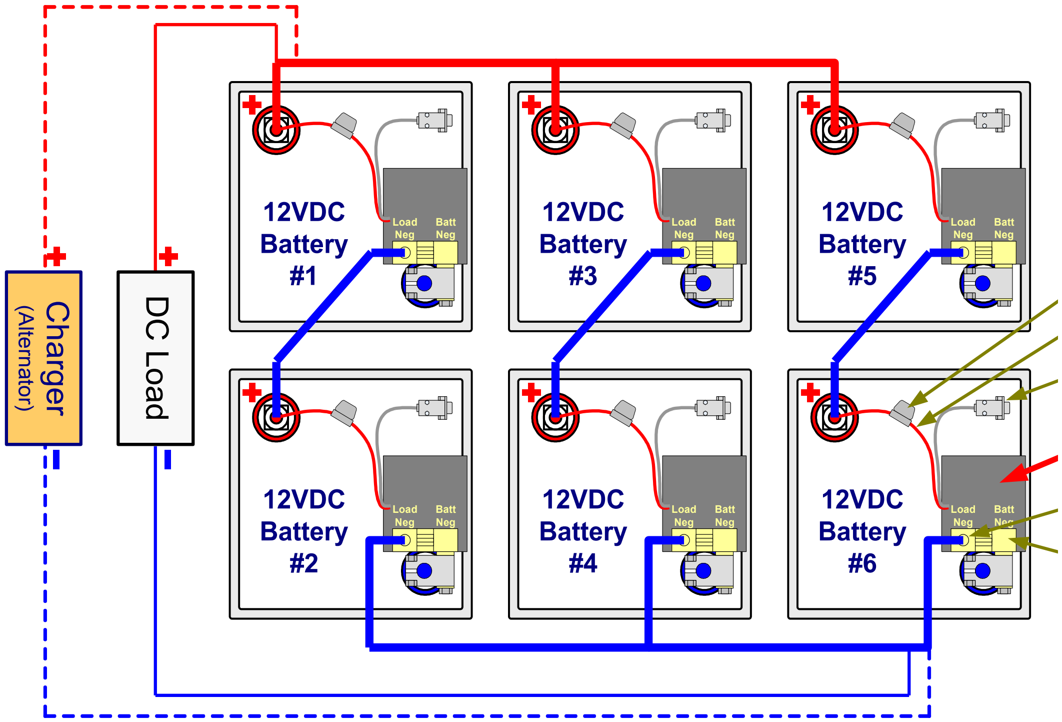
Configuration 1
System Level Monitoring Only



DATA	READINGS
SOH	System
SOC	System
V (Voltage)	System
HR (Hr Remain)	System
I (Current)	System
Temp	System

Advantage: SIMPLICITY

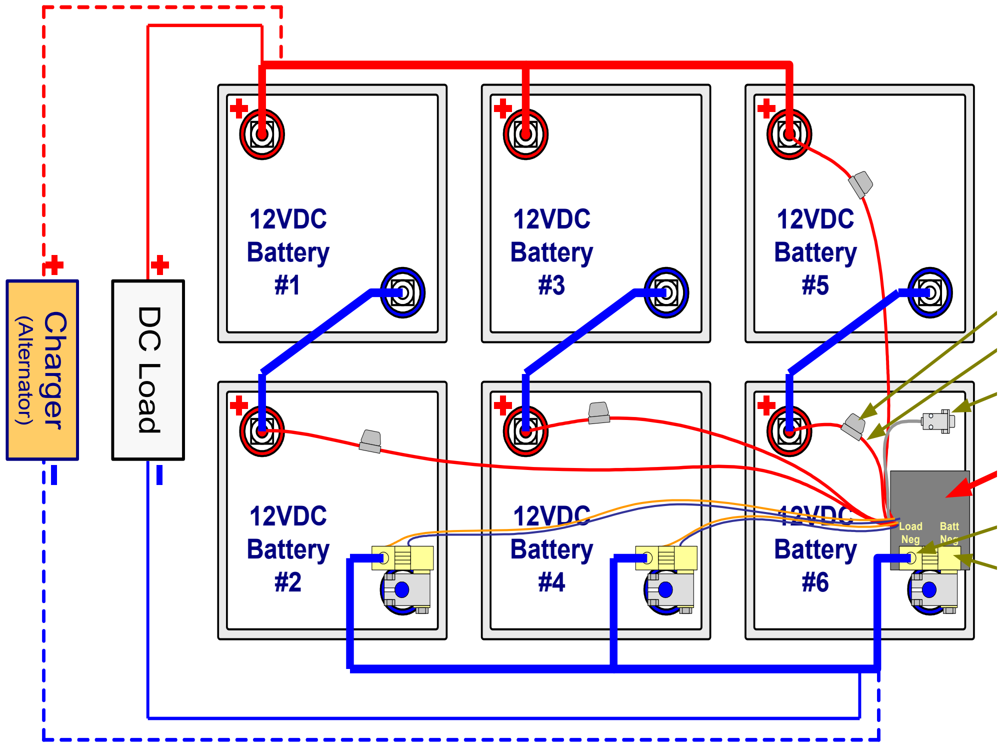
Configuration 2
Cell Level Monitoring Only



DATA	READINGS
SOH	Cell
SOC	Cell
V (Voltage)	Cell
HR (Hr Remain)	Cell
I (Current)	Cell
Temp	Cell

Advantage: PRECISION

Configuration 3
System/String/Cell Level Monitoring

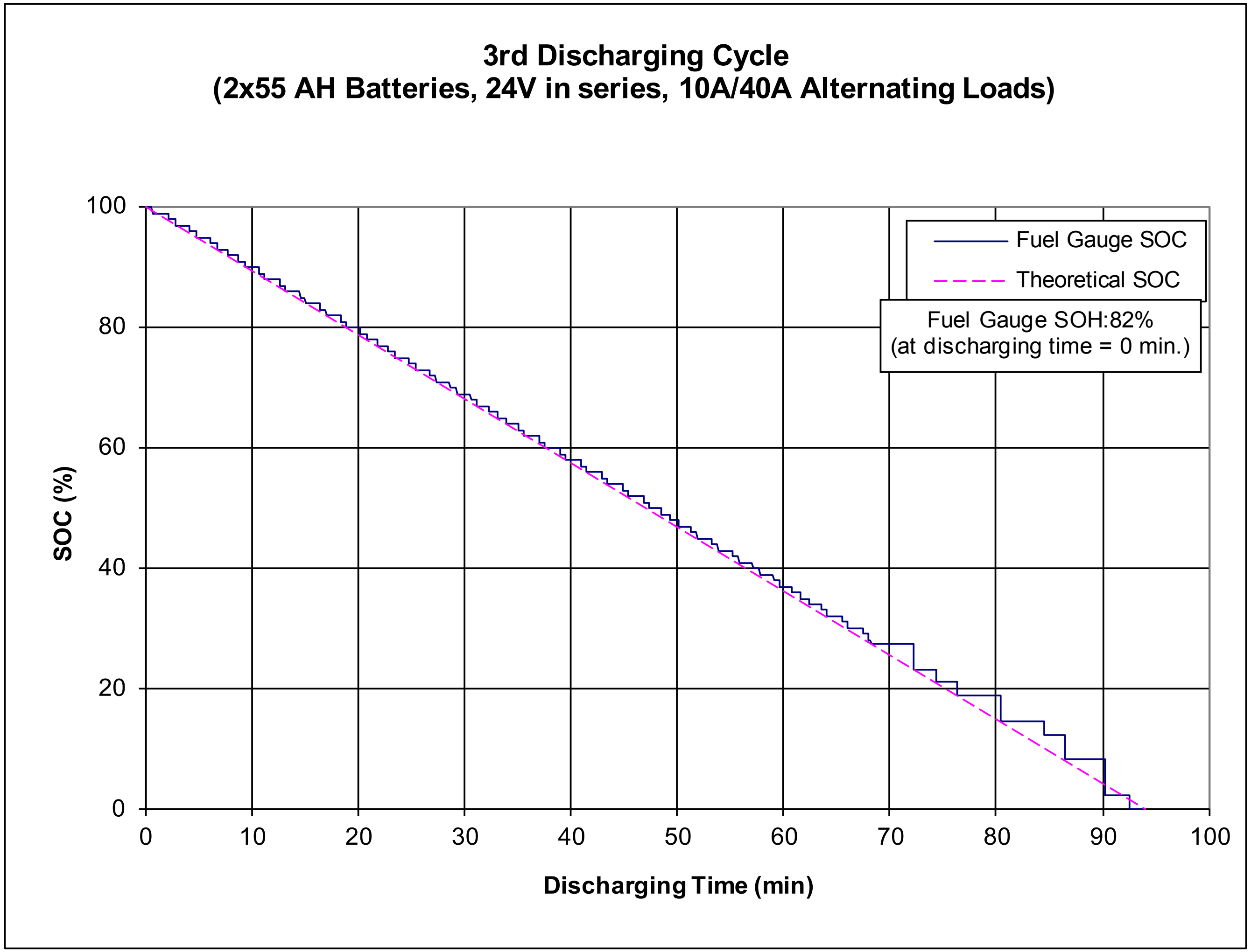


DATA	READINGS
SOH	Cell/String/System
SOC	Cell/String/System
V (Voltage)	Cell/System
HR (Hr Remain)	System
I (Current)	Cell/String/System
Temp	System

Advantage: SIMPLE, PRECISE & COST-EFFECTIVE

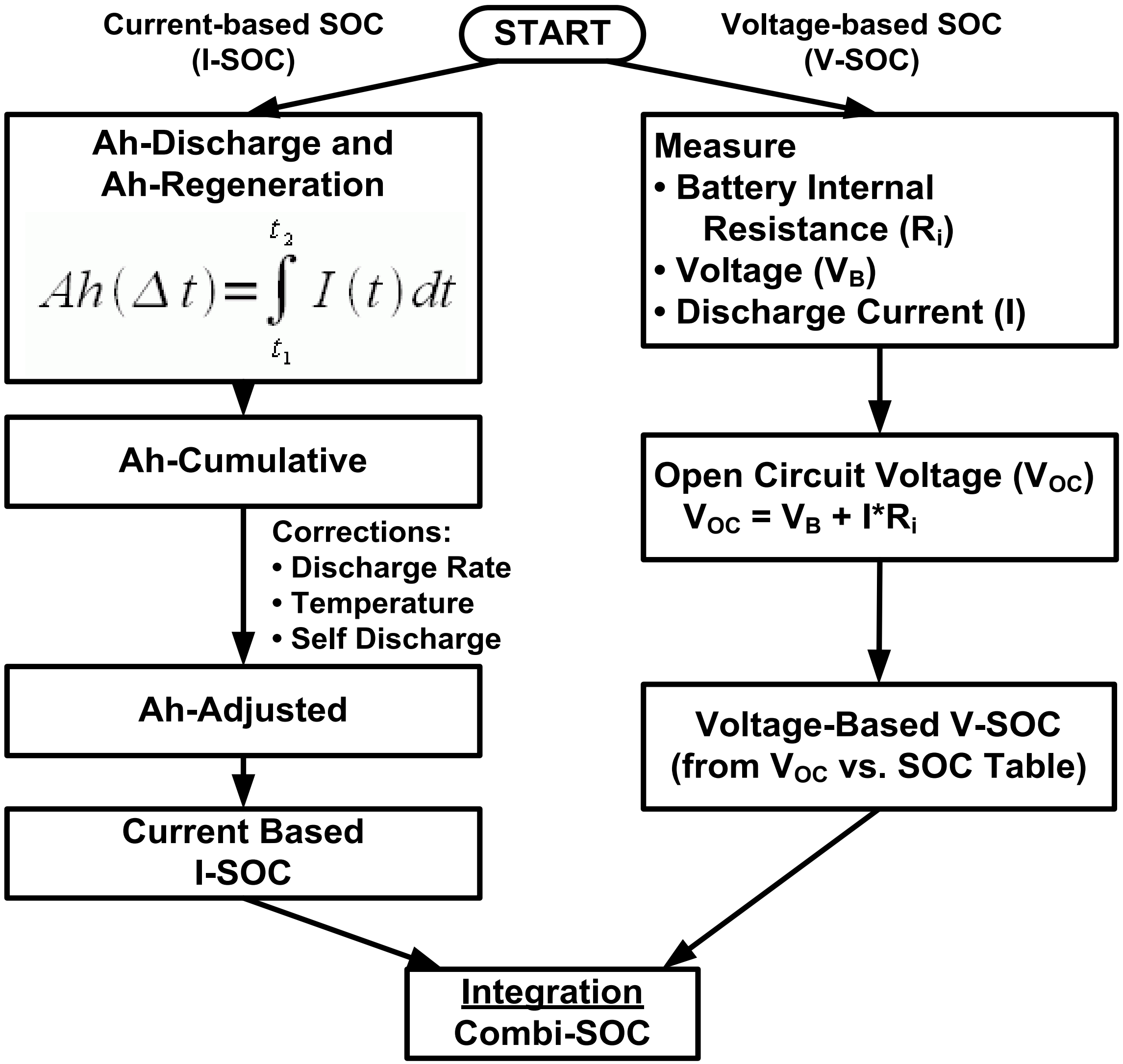
HDM's Battery Fuel Gauge Technology:
Dual Tracking Methodology

SOC Measurement

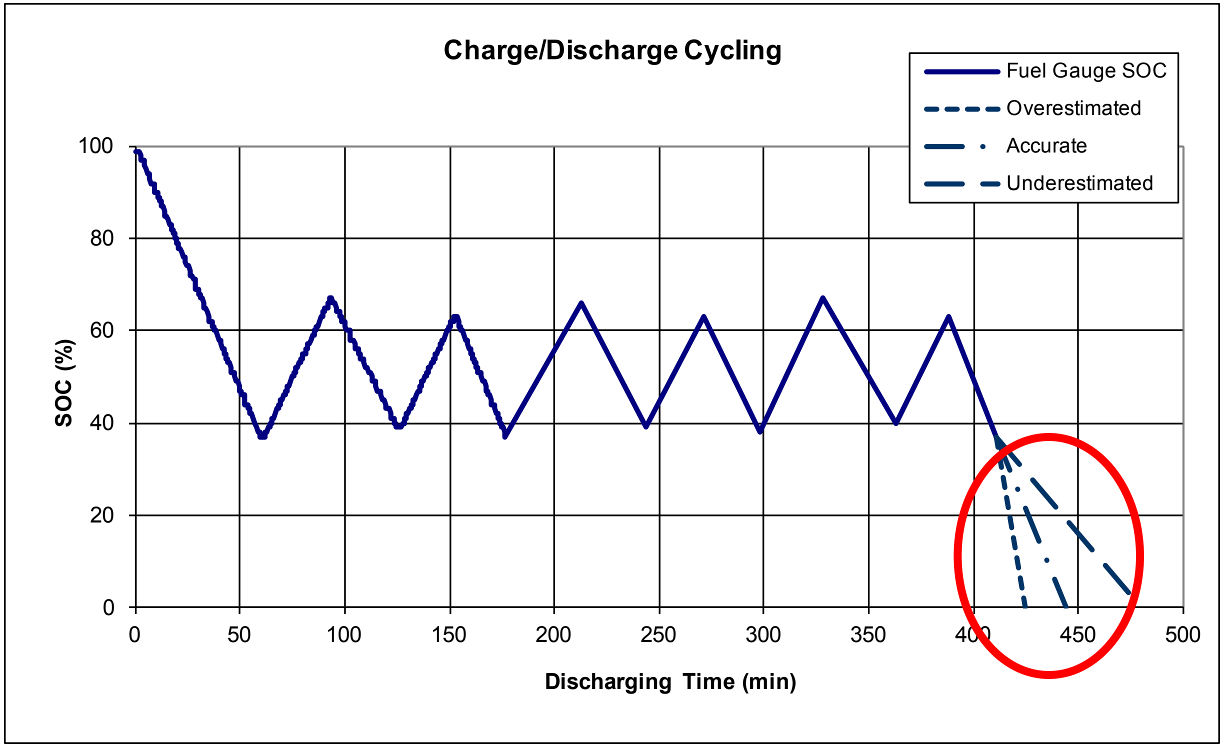


SOC Accuracy at 95%

Dual Tracking Voltage and Current Based SOC Derivation

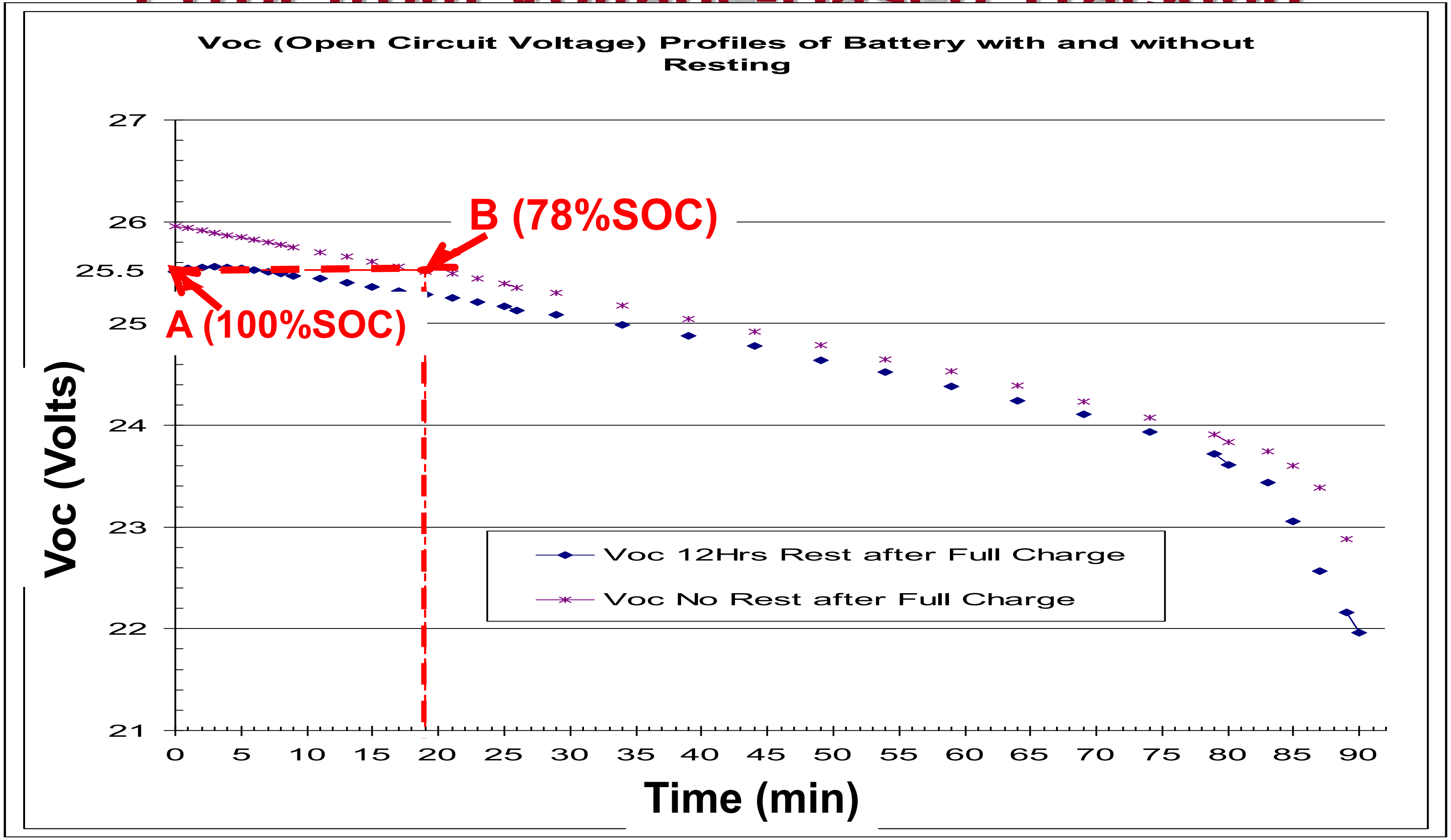


Error from Current-Based Tracking

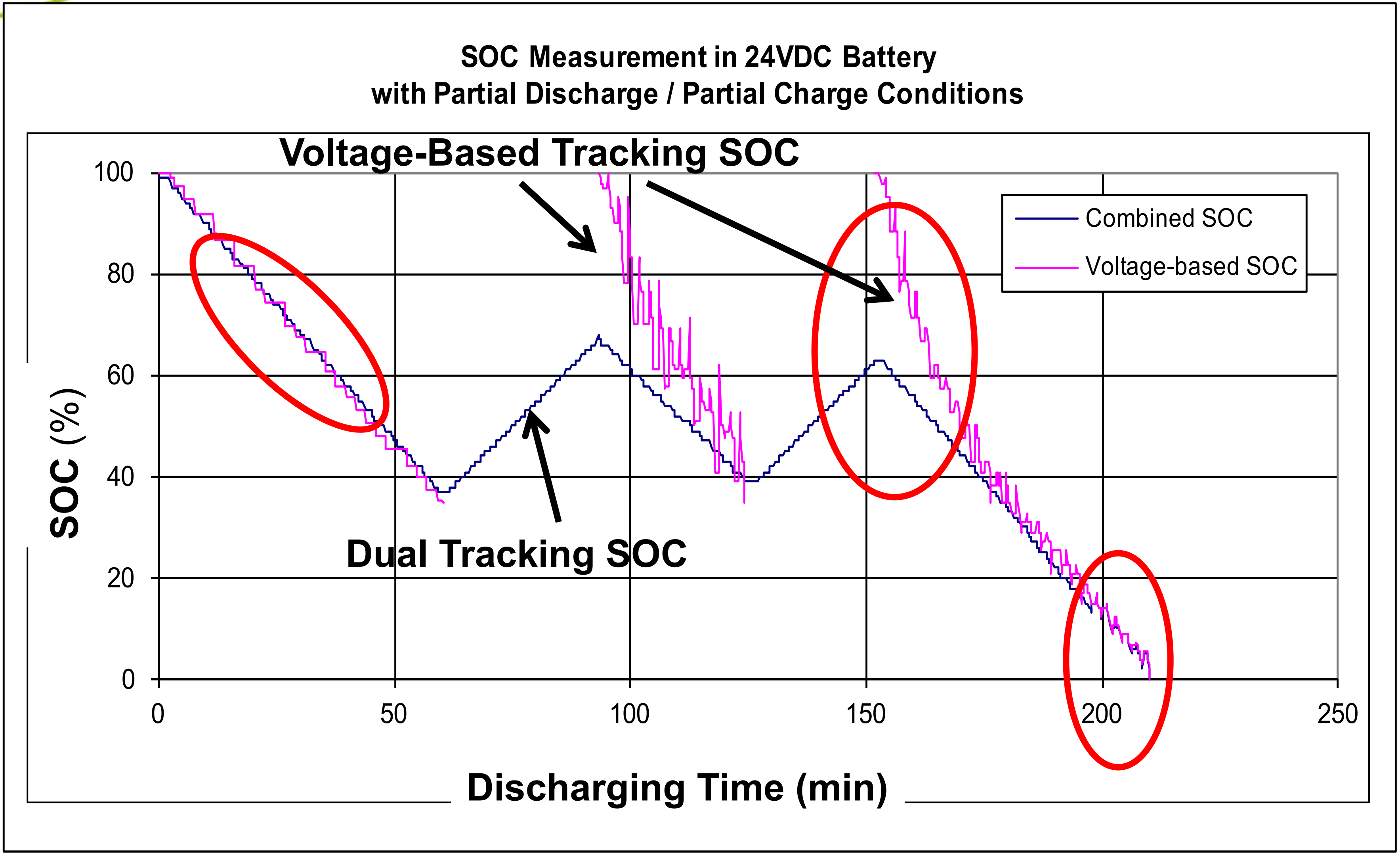


Lack of precise charge and discharge efficiency information results in accumulation of SOC estimation errors

Error from Voltage-Based Tracking

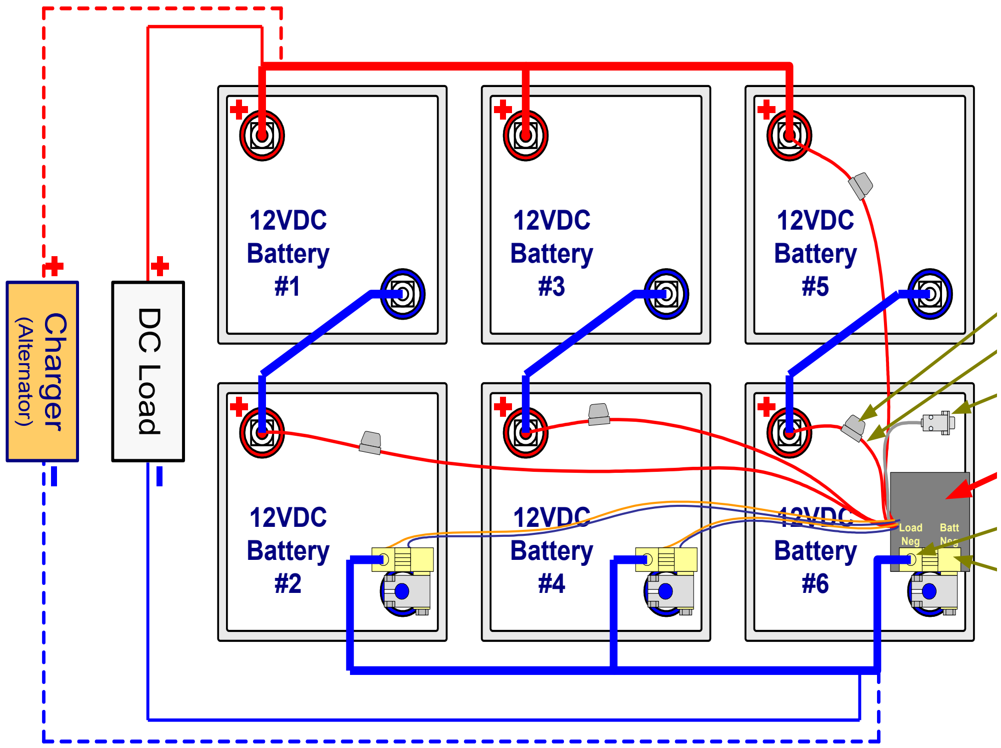


Lack of voltage relaxation results in SOC errors



Dual Tracking Method is optimal for all loading conditions

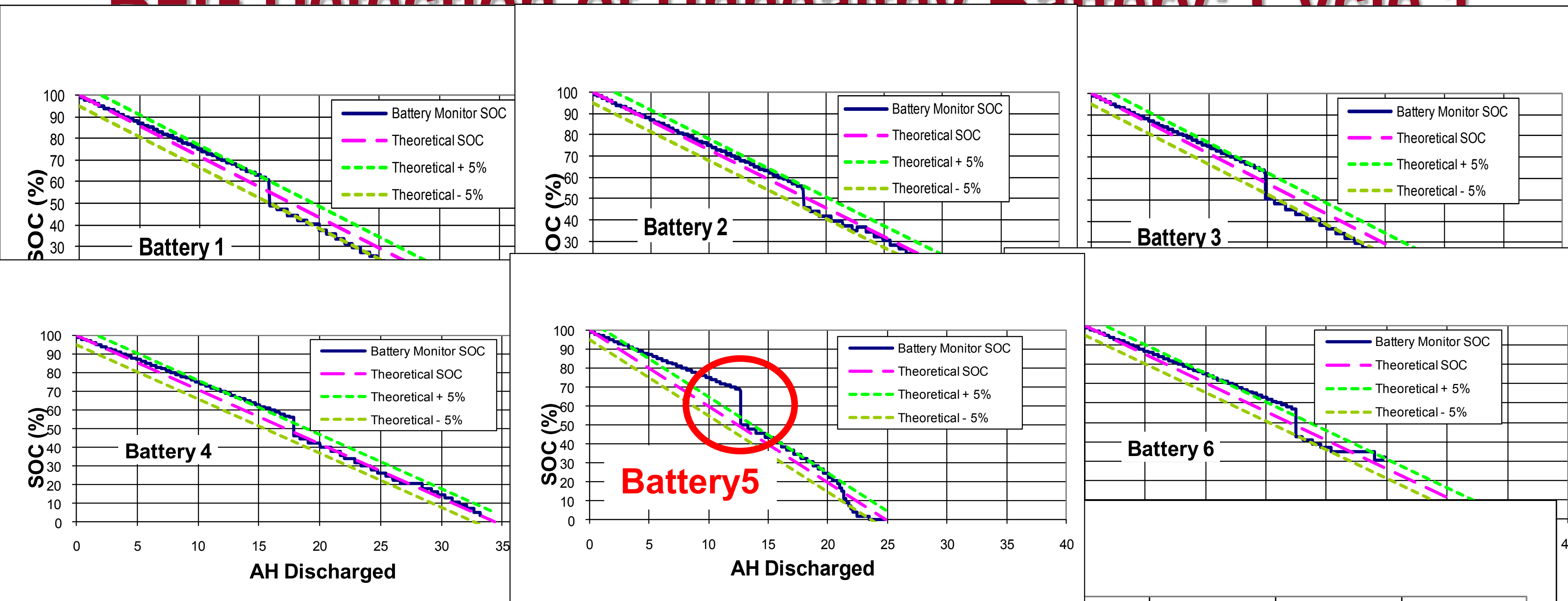
Configuration 3
System/String/Cell Level Monitoring

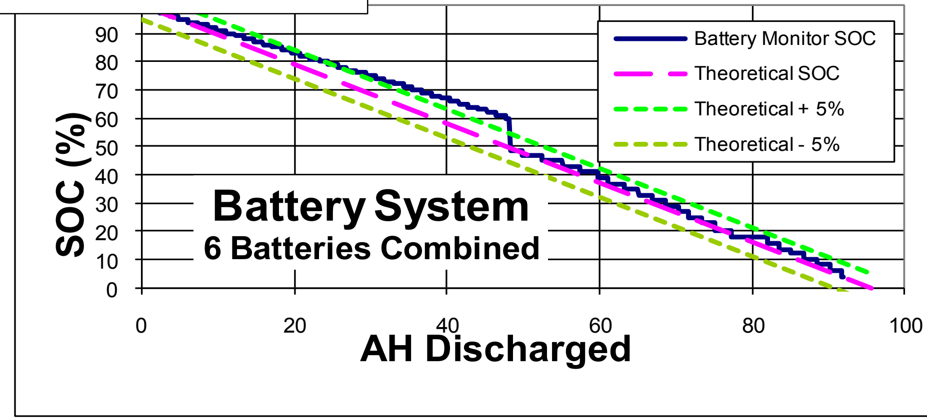


DATA	READINGS
SOH	Cell/String/System
SOC	Cell/String/System
V (Voltage)	Cell/System
HR (Hr Remain)	System
I (Current)	Cell/String/System
Temp	System

Advantage: SIMPLE, PRECISE & COST-EFFECTIVE

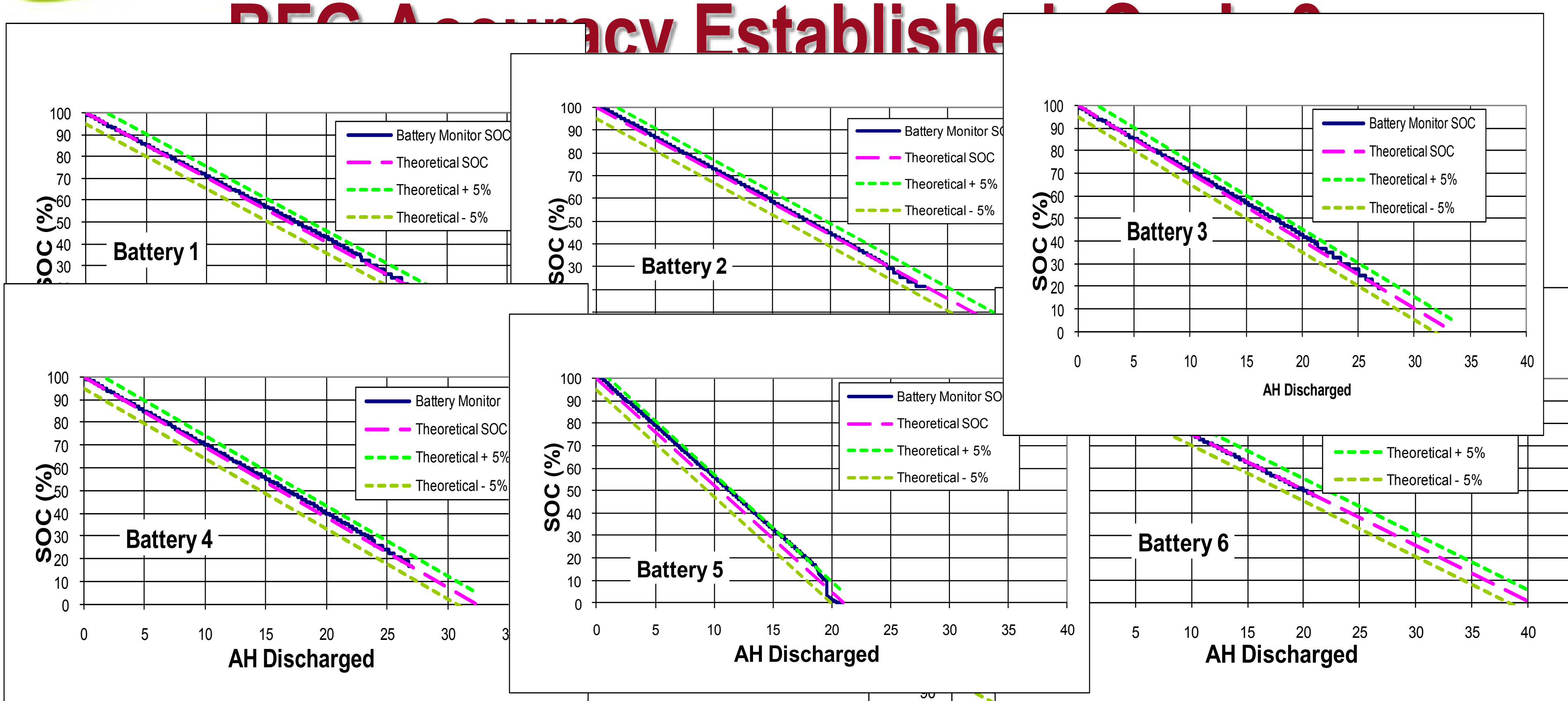
BFG Detection of Unhealthy Battery: Cycle 1



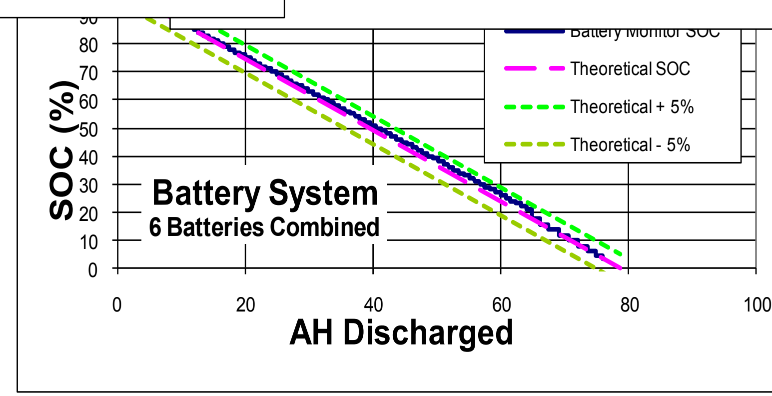


HDM BFG identifies weak battery during discharge cycle 1

BFG Accuracy Establishe



HDM BFG achieves 95% accuracy by discharge cycle 3 (i.e. no adjustments needed)



Effects of Unhealthy Battery on Bank 1*

String #	Battery #	Individual Battery Voltage @ End Point	Discharge Current From	To	SOC %	SOH %
1	1	11.3V	12A	19A	10	73
	2	11.5V			16	78
2	3	11.4V	10A	18A	12	71
	4	11.4V			12	73
3	5	10.8V	18A	4A	0	50
	6	12.0V			36	78
Sum 1 - 3	Sum 1 - 6	System Battery End Voltage: 22.8V	System Discharge Current: ~41A	~41A	0%	68%

* Battery Bank 1: Optima Batteries

- String 3: Divergence of voltage and reduction in discharge current cause **over-current stress on Strings 1 and 2**
- Premature termination of discharge cycle, resulting in **19% loss in usable capacity**

Effects of Unhealthy Battery on Bank 2*

String #	Battery #	Individual Battery Voltage @ End Point	Discharge Current From	To	SOC %	SOH %
1	1	11.3V	33A	49A	14	77
	2	11.4V			19	80
2	3	10.6V	33A	6A	0	55
	4	12.1V			51	93
3	5	11.2V	34A	45A	12	75
	6	11.5V			22	87
Sum 1 - 3	Sum 1 - 6	System Battery End Voltage: 22.7V	System Discharge Current: 100A	100A	0%	62%

* Battery Bank 2: Hawker Batteries

- String 2: Divergence of voltage and reduction in discharge current cause **over-current stress on Strings 1 and 3**
- Premature termination of discharge cycle, resulting in **17% loss in usable capacity**

Weakest Battery Threshold vs. Conventional Threshold at 21V

String #	Battery #	Battery Voltage		Discharge Current			Charge Current
		@ End Point 1 (Bat 3 SOC=0%)	@ End Point 2 (Bat Voltage=21V)	@ 100% SOC	@ End Point 1	@ End Point 2	@ Low SOC
1	1	11.3V	9.9V	36A	51A	20A	20A
	2	11.4V	11.1V				
2	3	10.6V	9.6V	30A	6A	65A	3A
	4	12.1V	11.5V				
3	5	11.2V	9.7V	36A	45A	17A	19A
	6	11.5V	11.3V				
Sum 1 - 3	Sum 1 - 6	22.7V	21.0V	102A	102A	102A	Set @ 42A

By extending the system run-time (e.g. by 30 minutes), would be at the expense of the weakest battery

Single BFG at 95% Accuracy for up to 6 Individual Batteries

- Provides breadth and depth necessary for Cost-Effective Battery Management Systems and CBM
- User Level
  - Ensures power system reliability and performance
- Maintenance Level
  - Enables precision pinpoint of unhealthy batteries for CBM
- Incorporates theoretically scalable algorithm, for banks greater than 6 batteries (i.e. important for larger, stationary energy storage systems)

Thank You!

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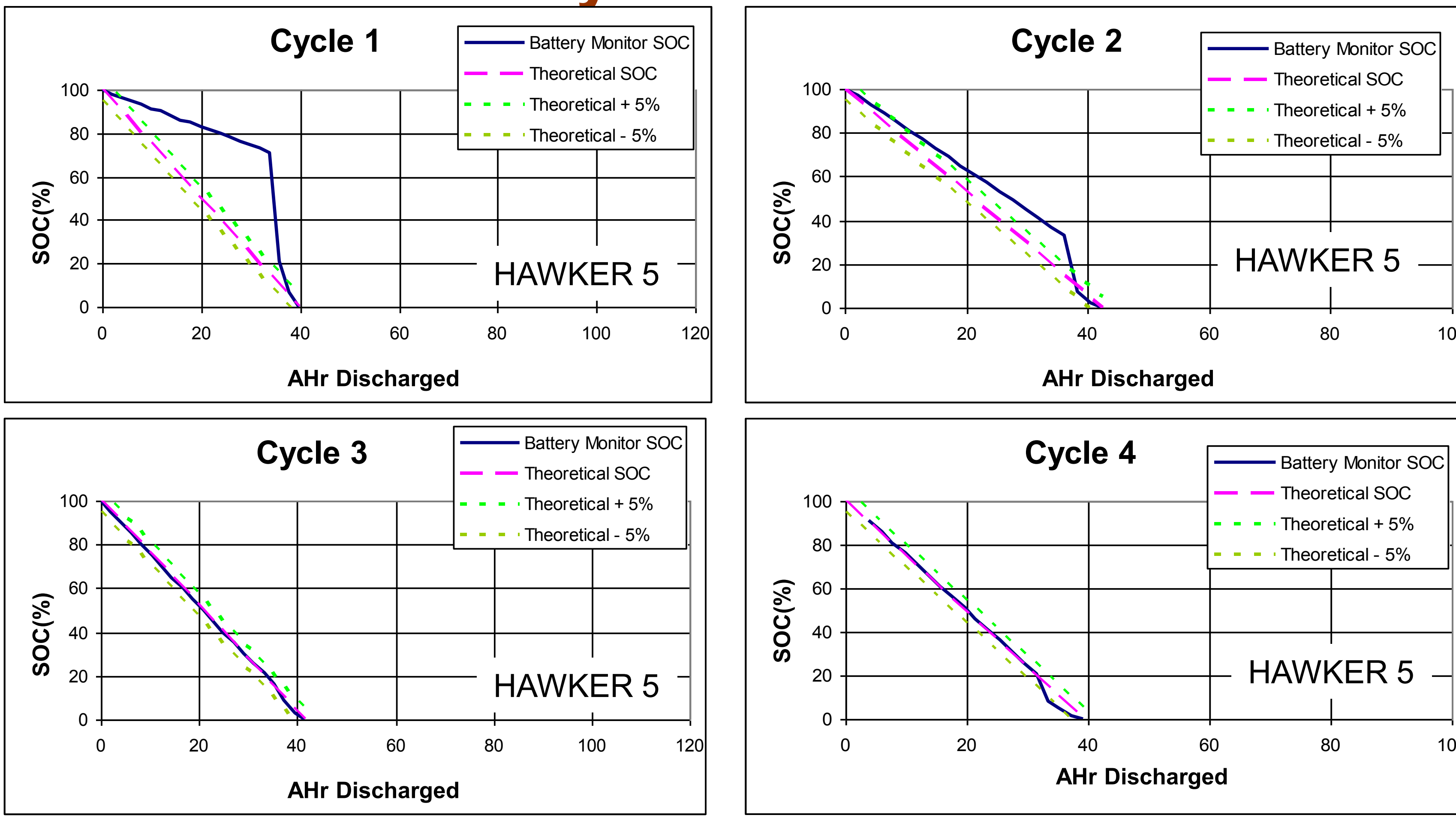
HDM Systems, Inc.
226 Lincoln Street
Allston, MA 02134
Tel: 617.562.4054
Fax: 617.562.4013

Web: www.HDM-Sys.com

Appendix

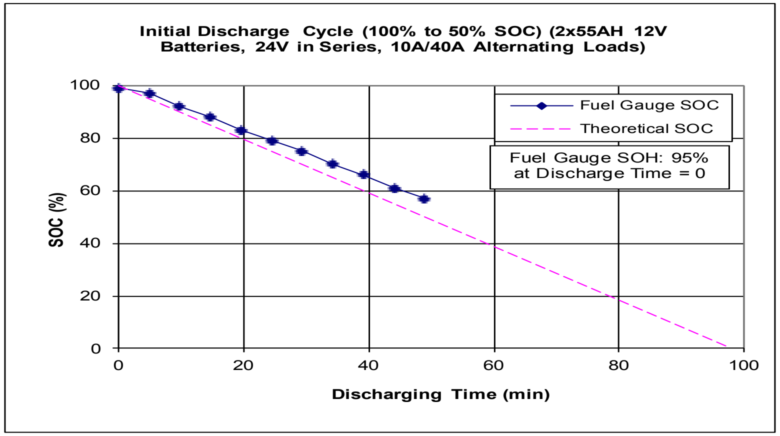
Dual Tracking: Battery 5 in Battery Pack 1,2,3,5 Cycles 1 to 4

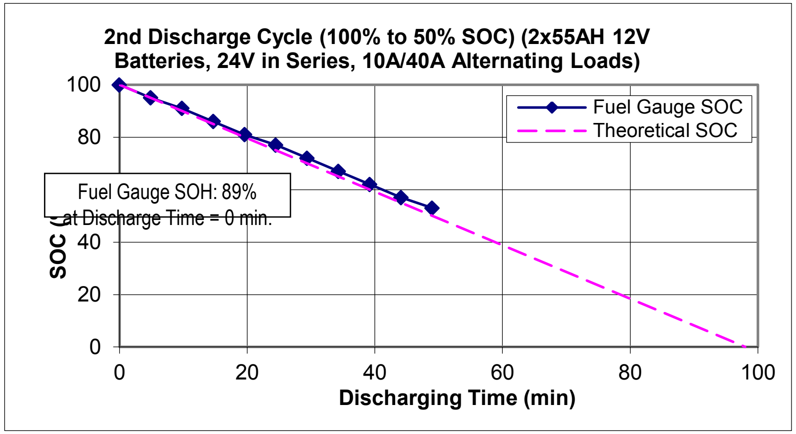


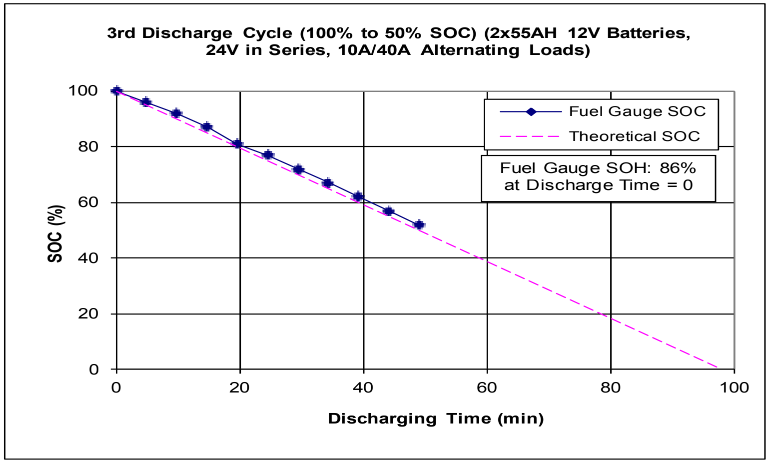
In a battery pack, HDM's BFG provides accurate SOC & SOH information within 2-3 cycles in a battery pack

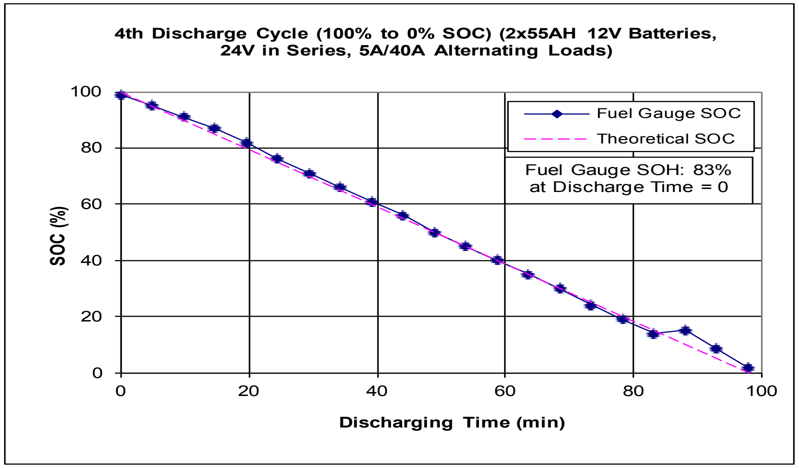
SOC Measured by Dual-Tracking Method

Scenario 2: Partial Discharge – Cycle 1 to Cycle 4



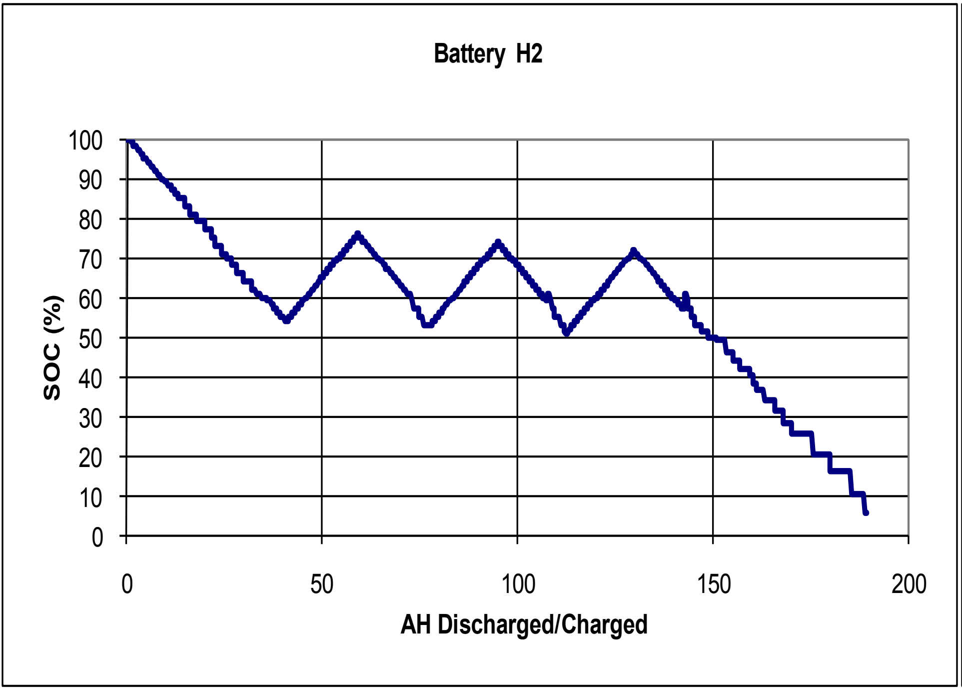


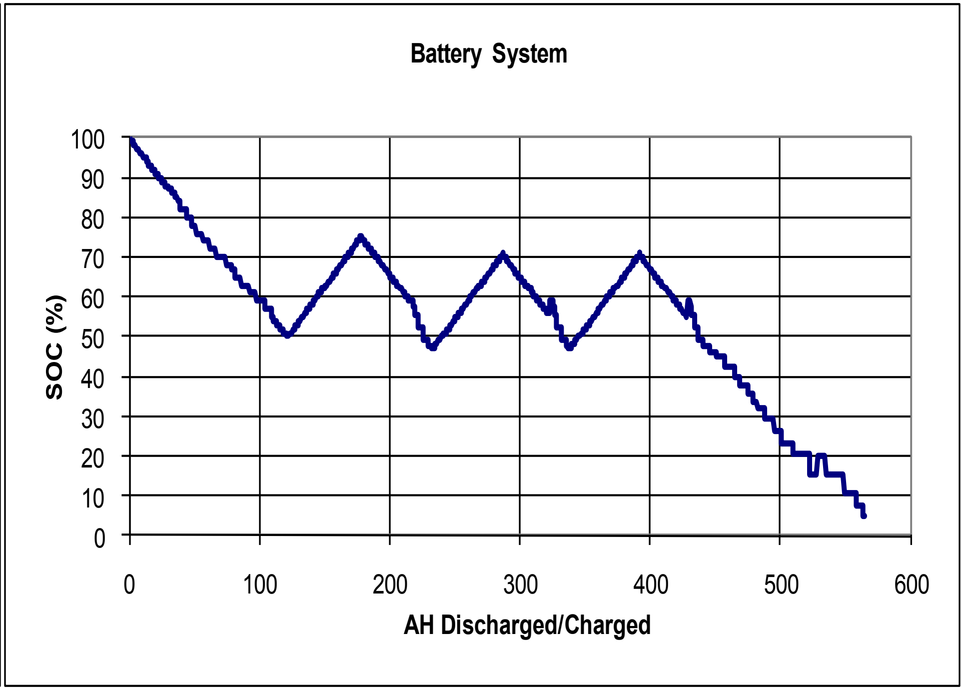




SOC error is within 5% at cycle 4

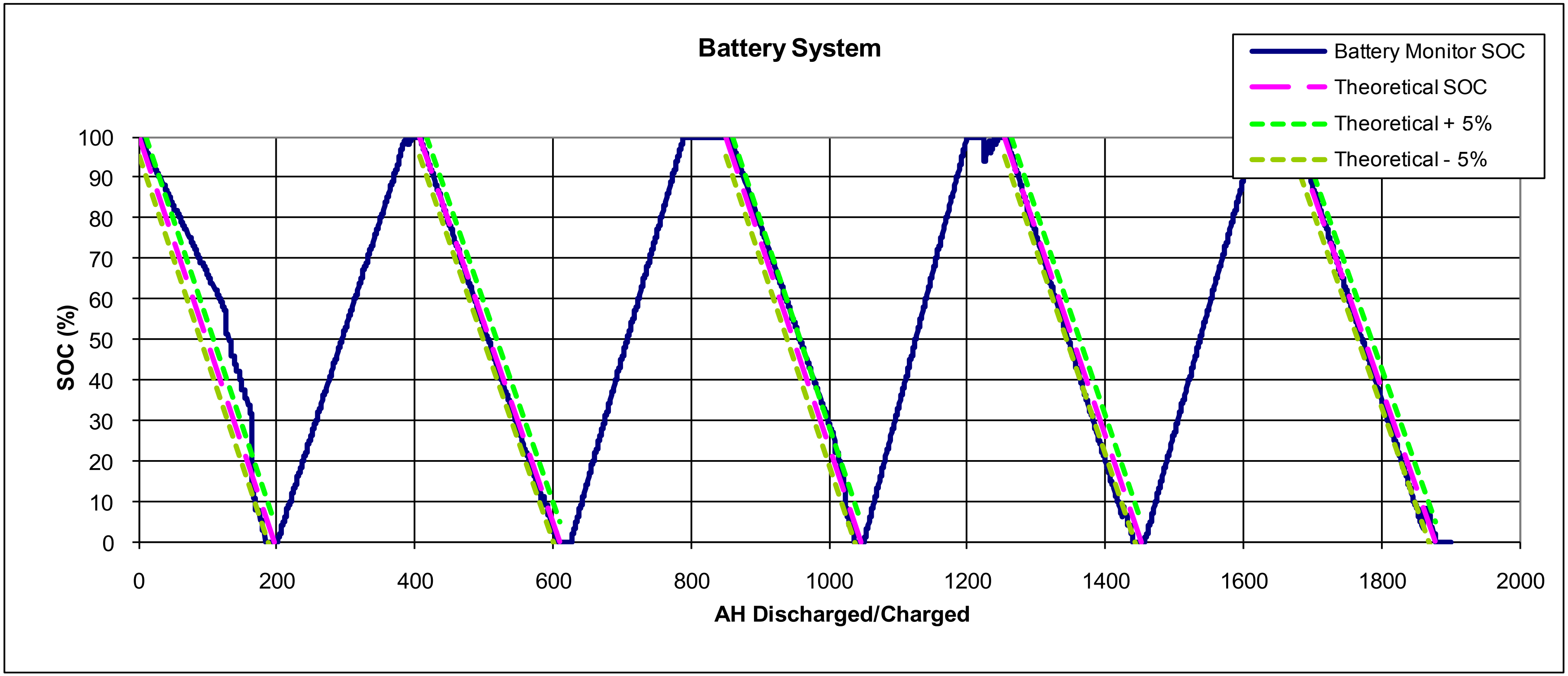
Partial Charge/Discharge Cycles of Battery Bank 2 – Battery #2/System





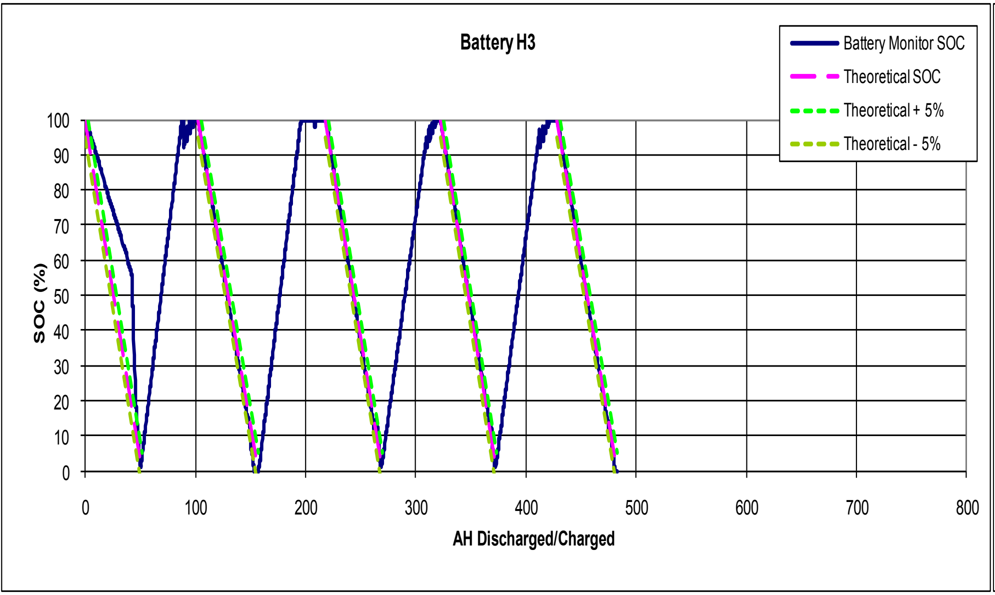
- SOC accuracy is 95% after four partial charge and discharge cycles

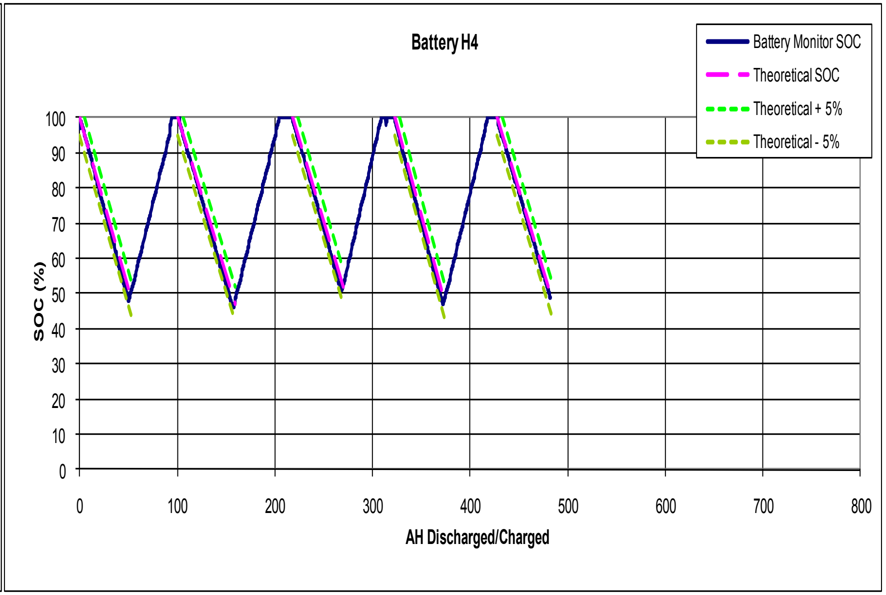
Whole Battery Bank (6 Batteries) Monitoring



- SOC accuracy is 20% in first cycle, it quickly improves to 5% within a few cycles
- Total AH discharge is measured around 200 AH
- System discharge termination point: is set when any battery in the system reaches a low voltage of 10.5V

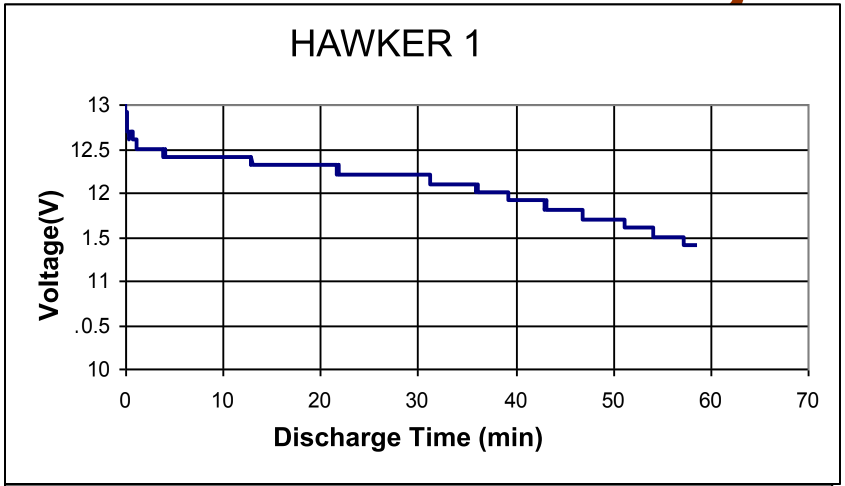
5-Cycle-Profile of 2nd String of Batteries (3&4)

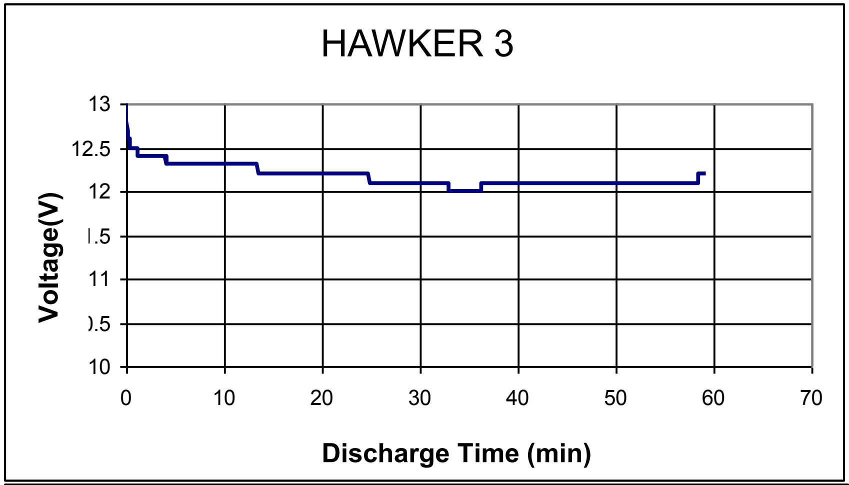


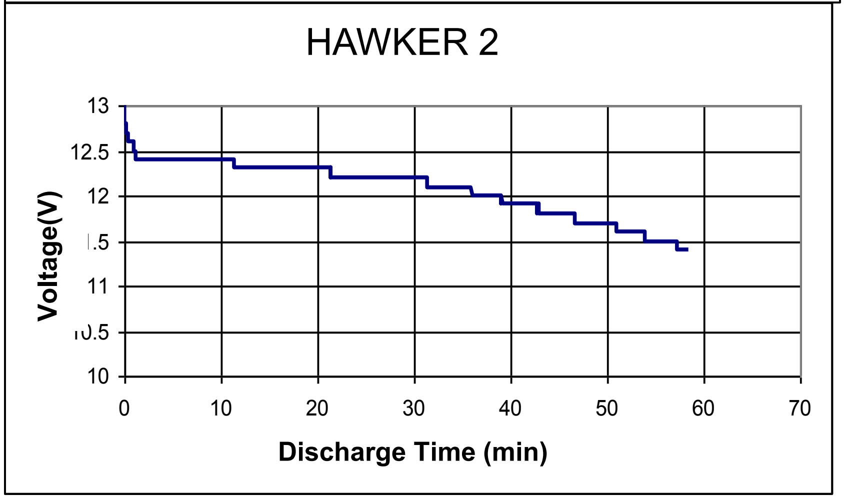


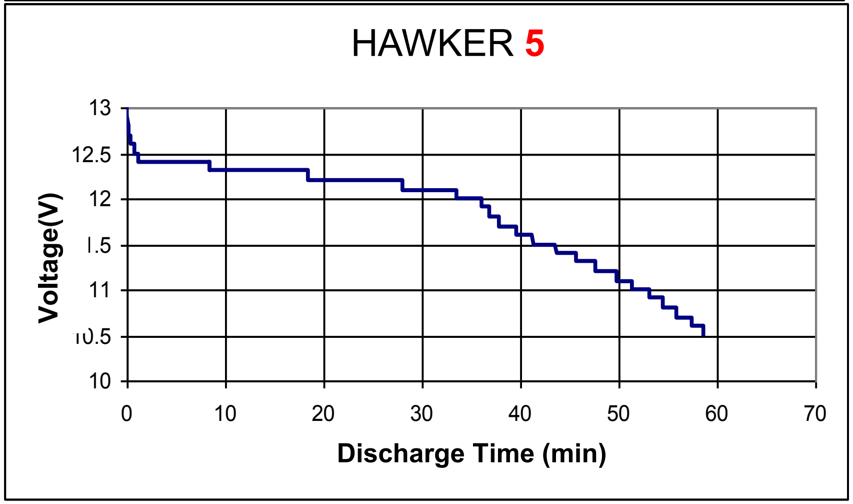
- Battery #3 is the weakest. SOH ~ 50%, other batteries are 75% to 80%
- At 1st cycle, SOC of battery #3 is 40%. After a few cycles, SOC is within 5% error
- Battery #3 capacity is only 50Ah and is fully utilized when the system reaches the termination point
- Battery #4 in the same string only used up 50% capacity when system reaches the termination point

Voltage vs. Discharge Time of Battery Pack 1,2,3,5 Cycle 1



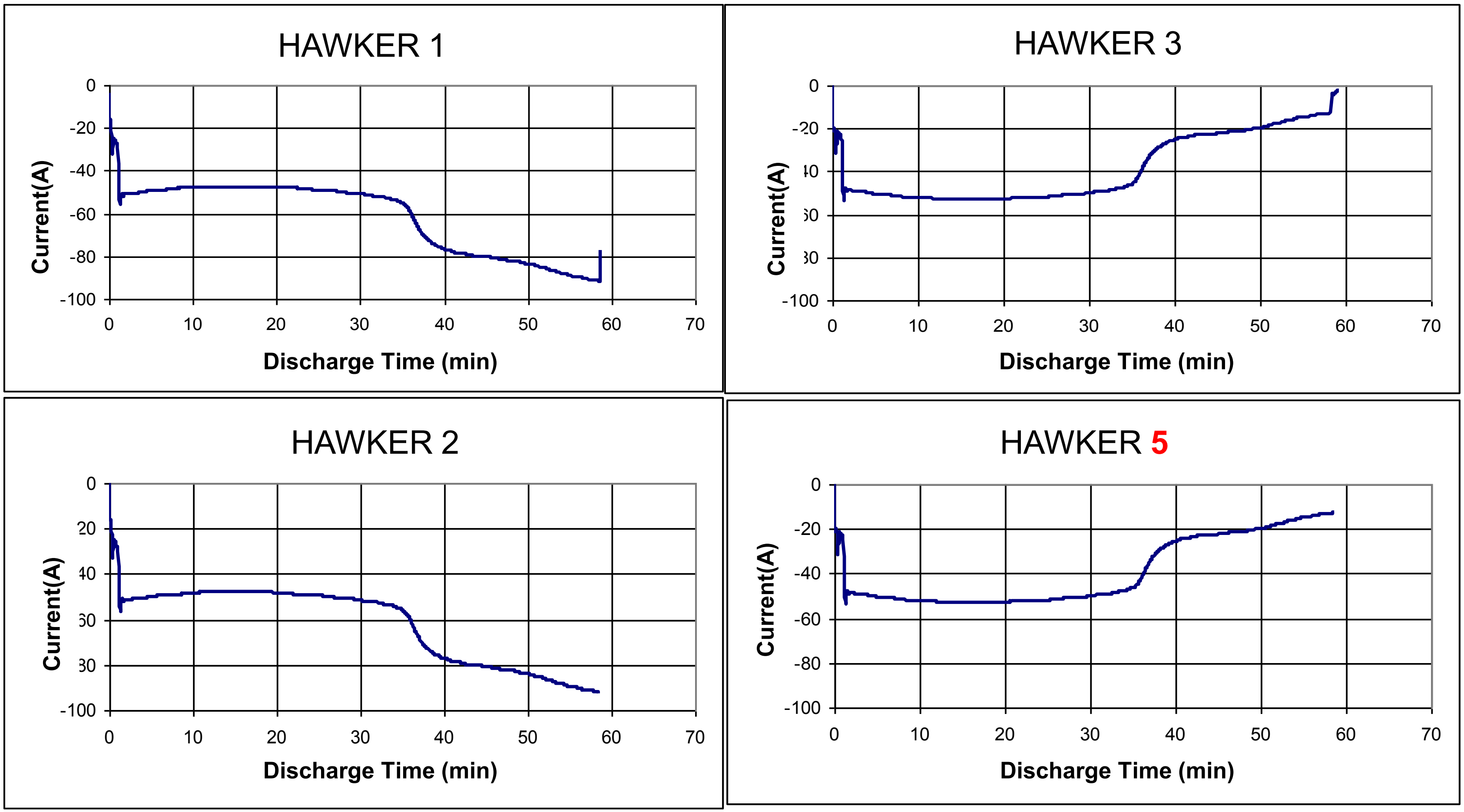






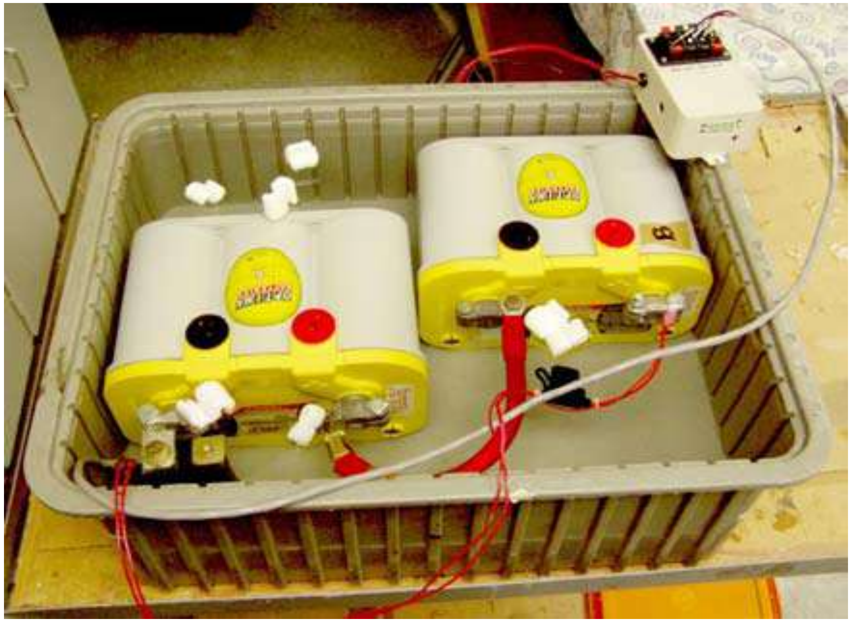
Bad battery causes battery voltage divergence in a battery pack

Current vs. Discharge Time of Battery Pack 1,2,3,5 Cycle 1



Bad battery causes discharging currents unbalanced between battery strings (1&2) vs. (3&5)

BFG: Water Submersion Test



BFG was submersed in water at 25°C for three hours, and was tested for operational performance

Joint Service Power Expo 2011

Battery Management
and Sustainment System

PulseTech Products Corporation

Presented by:

PulseTech Products Corporation

Mark Abelson

800-580-7554, ext. 167

817-307-5603 (cell)

mabelson@pulsetech.net

www.pulsetech.net

Battery Failure in 24 Volt Systems

- Most 24V systems are made up of multiple batteries in series or series parallel
- Failure occurs for a variety of reasons
  - – Received “new” in an undercharged condition
  - – Never fully recharged
  - – Key off loads
  - – Parasitic drains
  - – Environmental
  - – Battery set imbalance
    - 12 Volt Taps
    - Dissimilar Chemistries

Battery Imbalance

Effects

1. Premature Battery Failures
2. Premature Alternator Failure
3. Differing Internal Resistance

Causes

1. 12 Volt Taps
2. Lack of Testing – *new* and used batteries
3. Mismatched Installs

Corrective Actions

1. Testing
2. Matching battery set/pack voltages
3. Recharging low SOC battery in the pack *before* attempting 24v charging (either charger or alternator)

PulseTech Products Corporation

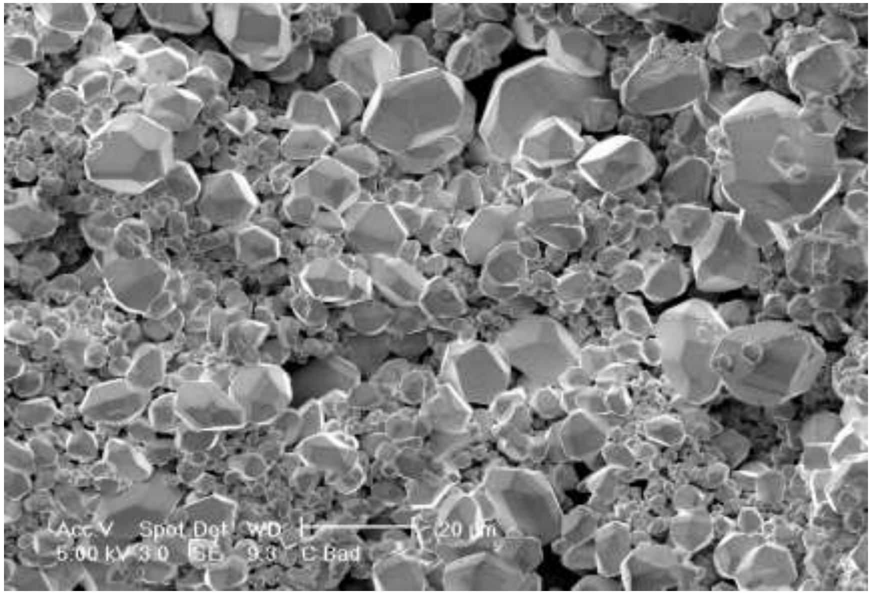
Impact on Battery Performance

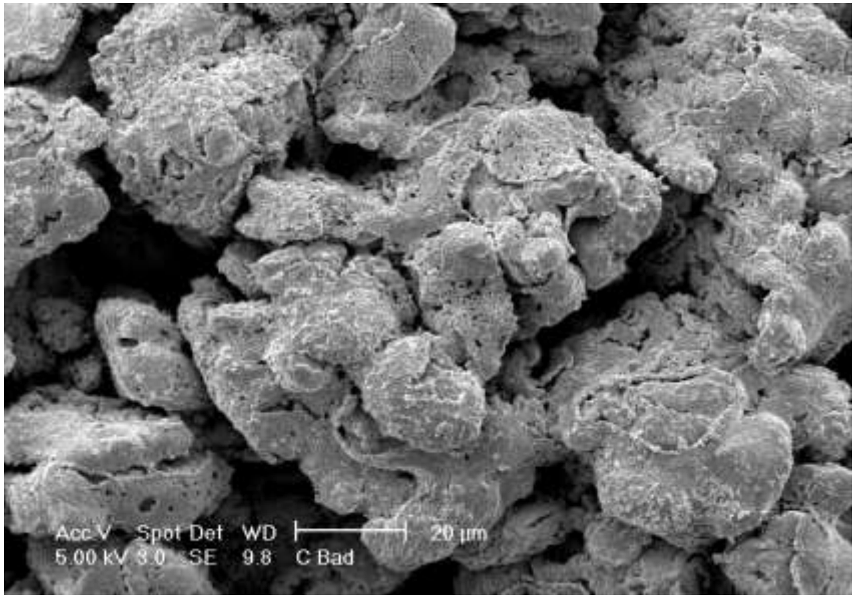
- Lead Sulfate Build up---Enlarged Crystals
- All L/A batteries create $PbSO_4$
  - AGM – slower formation
  - Flooded Cell- faster formation
  - Heat accelerates self discharge/crystal formation

Common Causes of Battery Failure

PulseTech Products Corporation

Ohio State University
5-yr. old fully charged batteries





Cathode crystalline structures remaining after charging without pulsing

Cathode after charging with pulsing

PulseTech Products Corporation

Impact on Battery Performance

- Overall capacity is reduced
- Starting issues begin to increase
  - Heat
  - Cold
- Shorter “silent watch” times
- Insulating layer of crystals

- Premature battery replacement

Operational & Financial Impact of Battery Failure

- Equipment Not Mission Capable
- Shrinking O&M budget spent on batteries
- Man-hours wasted on replacing batteries
- HAZMAT requirements
- RBE whole fleet battery replacement

Overcoming Battery Problems

- Goals
  - Minimize handling batteries
  - Keep them in the vehicles
- Training at every level
- Testing
- Preventive Maintenance
- Corrective Maintenance

490 PT and MBT-1

Part Nos. 741x490 and 741x800

(NSNs: 6130-01-510-9594 and 6130-01-463-8499)

PM Goal

KEEP BATTERIES IN VEHICLES

- Solar Chargers

- Pro-HD's

Corrective Shop Maintenance

- When batteries are too far gone to be recharged/recovered in the vehicle

  Caused by:
  - Imbalanced set
  - Short run times
  - Too many add-on loads
  - Low output alternator
  - Mixed chemistries
  - Sitting too long without Solar Maintenance Charging (RBE)
  - How long is too long?

Corrective Shop Maintenance

<u>HD Pallet Charger</u>
Part No. 746x820
NSN: 6130-01-532-7711

<u>Redi-Pulse Pro HD</u>
Part No. 746x800
NSN: 6130-01-500-3401

<u>Pulse Charger/World Version</u>
Part No. 746x725
NSN: 6130-01-477-4703

<u>490PT</u>
Part No. 741x490
NSN: 6130-01-510-9594

<u>Redi-Pulse Pro-12</u>
Part No. 746x912
NSN: 6130-01-535-2718

<u>Battery Service Equipment Set (BSES)</u>

- 1 – HD Pallet Charger
- 1 – Redi-Pulse Pro-HD 12/24V Charger
- 1 – Redi-Pulse Pro-12
- 10 – MBT-1 Battery Testers
- 1 – 490PT Battery Analyzer

"Initially we didn't think it was going to be anything other than additional charging stations, but immediately we found that we could recover twice as many batteries using the technology incorporated into the BATTCAVE Chargers." ***DOL – Fort Lewis***

Steps to Minimizing battery failures for operational and stored batteries!

- Test all batteries-new or used prior to installation and disposal
- Attempt recovery on all batteries to be disposed of (except those with bad cells or physical damage)
- Ensure battery packs have batteries of the same construction
- Match battery voltages
- Ensure terminals and cable clamps are clean and tight
- Test batteries during weekly PM to catch potential problems before they start to destroy capacity
- Keep batteries clean to prevent external shorts caused by acid or ferric compounds
- Avoid 12v taps on 24v systems – (step down transformers)

Conclusion

- **Many battery failures are preventable**
- AGM (Hawker, Optima) can have over 6 yr service life
- Flooded Cell (6T's, 2/4HN, Grp 31's) can have over 3 yr service life
- Stop by PulseTech Products Booth 215 for more information!

US ARMY RDECOM

U.S. Army Research, Development and Engineering Command

CERDEC

US ARMY – RDECOM

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

INTELLIGENT POWER MANAGEMENT DISTRIBUTION SYSTEMS (IPMDS)

April 2011

Outline

1. IPMDS Overview
2. Background
3. Automatic Load Balancing
4. IPMDS
5. Testing/Fielding Schedule

Description

- IPMDS – Intelligent Power Management Distribution System
- Man portable, ruggedized power distribution system
- Automatic load balancing
- Electrical hazard warnings
- Use with Tactical Quiet Generators (TQGs), 15kW – 100kW
- 208 V, 3 phase, Wye configured, 50/60 Hz

Benefits

- Reduce burden on the warfighter during power grid set up
- Increase power grid reliability
- Reduce injuries due to electrical hazards
- Near-term solution
- No increase in power distribution system footprint

Background

PDISE (Power Distribution Illumination System, Electrical)

- Principal distribution system for the U.S. Army
- Fielded by Project Manager Mobile Electric Power (PM-MEP)
- M400, M200, M60, M40, M46 and Universal Adapter.
- Currently greater than 10,000 pieces of PDISE equipment are in the field.

<u>M200 Feeder System</u>
200 amp, 3-phase input → 3-phase outputs

↓

<u>M100 Feeder System</u>
100 amp, 3-phase input → 3-phase outputs

↓

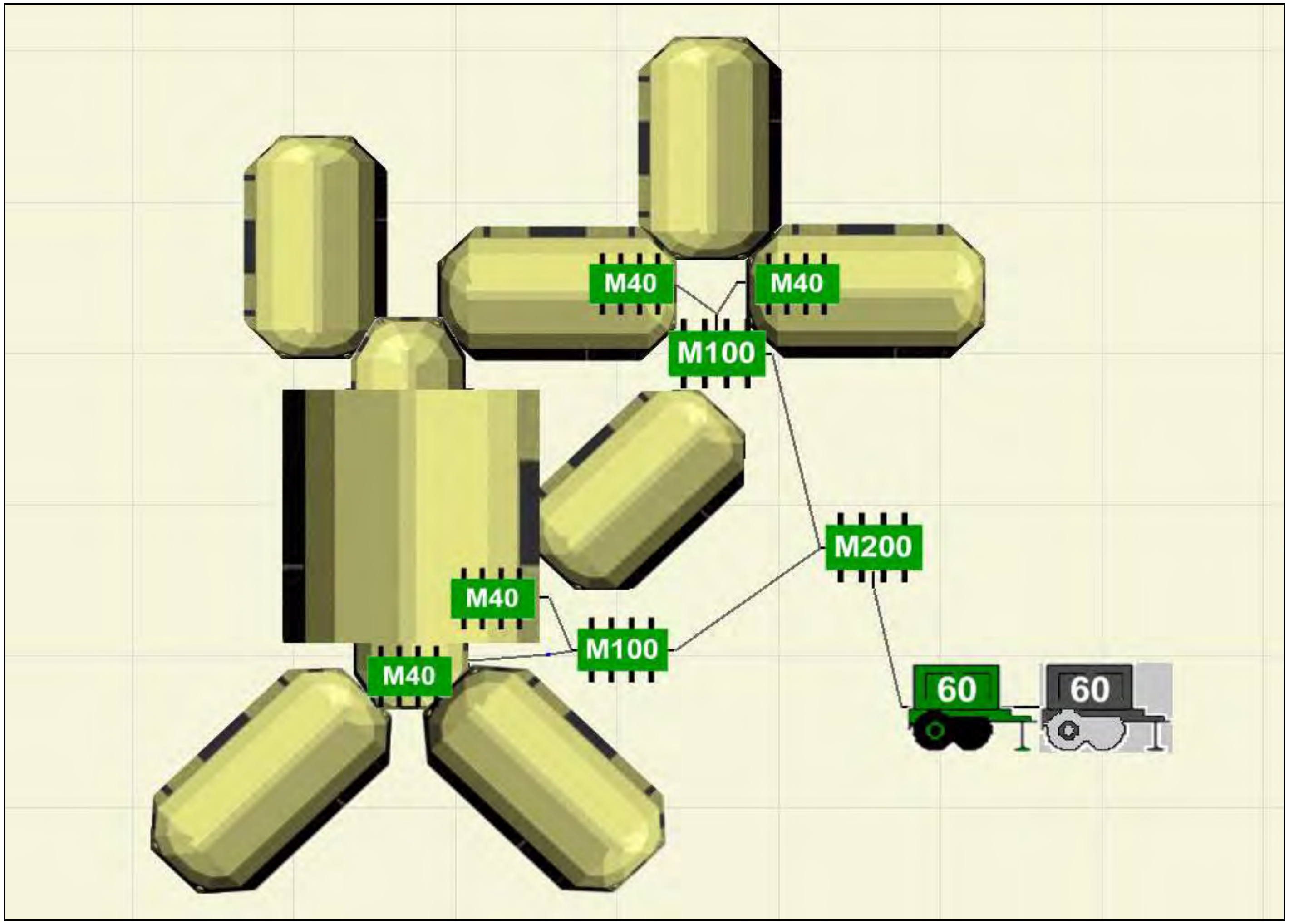
<u>M40</u>
60 amp, 1-phase input → 1-phase outputs

↓

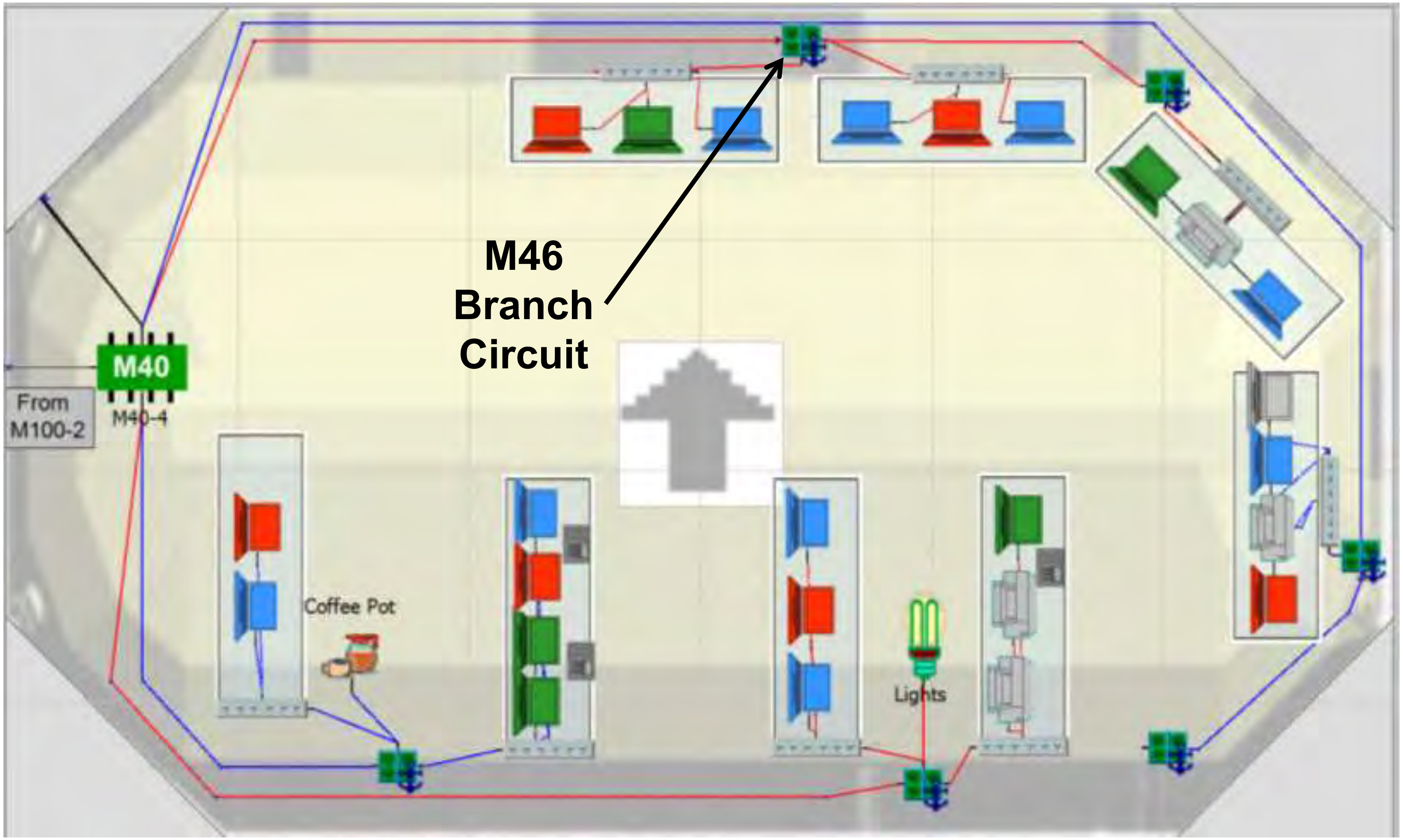
<u>M46</u>
Dual Duplex Receptacles, No GFCI

M200, M100, M60, and M40

Example Main TOC



Example Main TOC



Mission: Identify path to provide improved, near-term power distribution capabilities to soldiers.

Team: IPT consists of CERDEC, PM-MEP and CASCOM with support from Power & Energy IPT as needed.

Field Survey:

2007

– IPM IPT interviewed units returning from Iraq and Afghanistan.

- SBCT1
- SBCT2
- SBCT3
- 28th CSH
- 21st CSH
- 4th Psy Ops
- 782 BSB
- 659 Eng. Equipment
- 4th ID
- III Corps
- 82nd Airborne
- 35th Signal Brigade

–Created online questionnaire to receive input from additional users.

IPM Team Findings

1. Lack of knowledge regarding power grid set-up; poor set-up was primary cause of problems with power grids.
   IPMDS makes power grid setup more user friendly.

2. Improper balance of loads across three phases of generator sets was very prevalent.
   IPMDS automatically balances the loads and allows for maximum utilization of the distribution equipment.

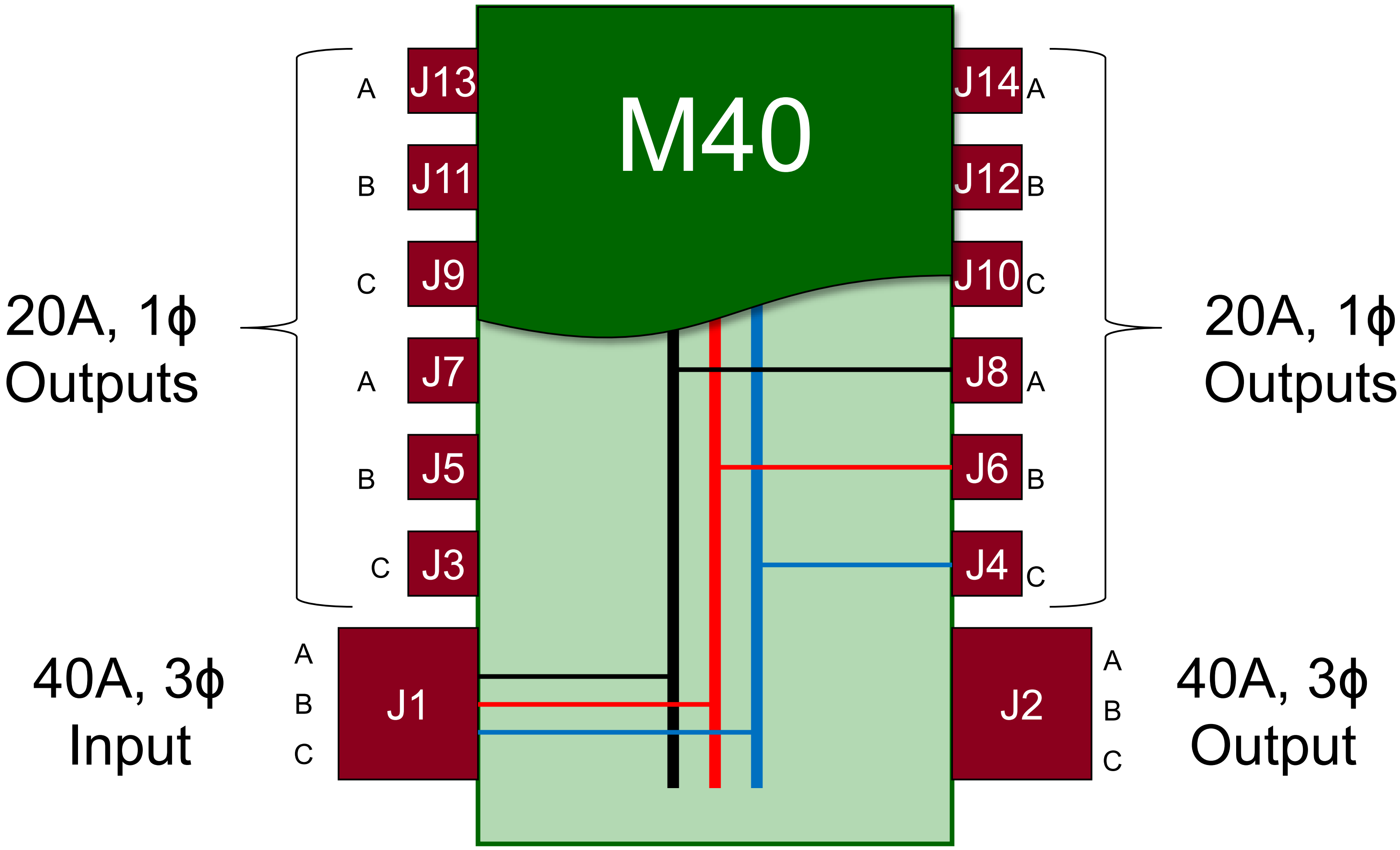
3. Uninterruptible Power Supplies (UPS) are insufficient to cover power outages.
   IPMDS can help avoid power outages due to circuit breaker tripping from a single phase overload and certain generator failures.

Automatic
Load Balancing

Automatic Load Balancing

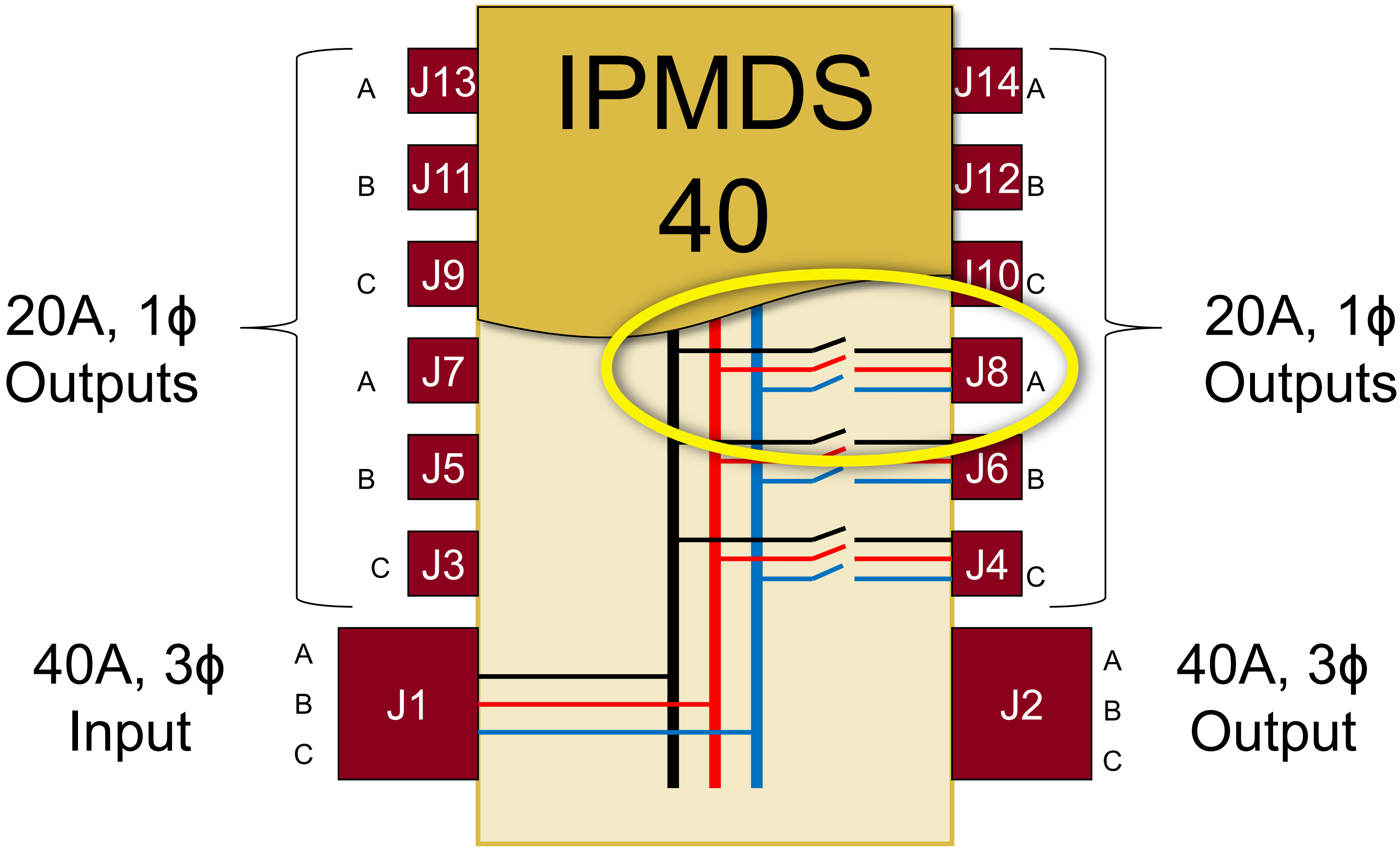
- **What is automatic load balancing?**
  - Autonomously ensures the load is shared equally across all three phases.
  - With IPMDS it is achieved through a controller and switching devices inside the distribution box.
- **Why is load balancing important?**
  - Circuit breaker trip avoidance
  - Vibration
  - Stator core heating
  - Voltage imbalance

Current M40

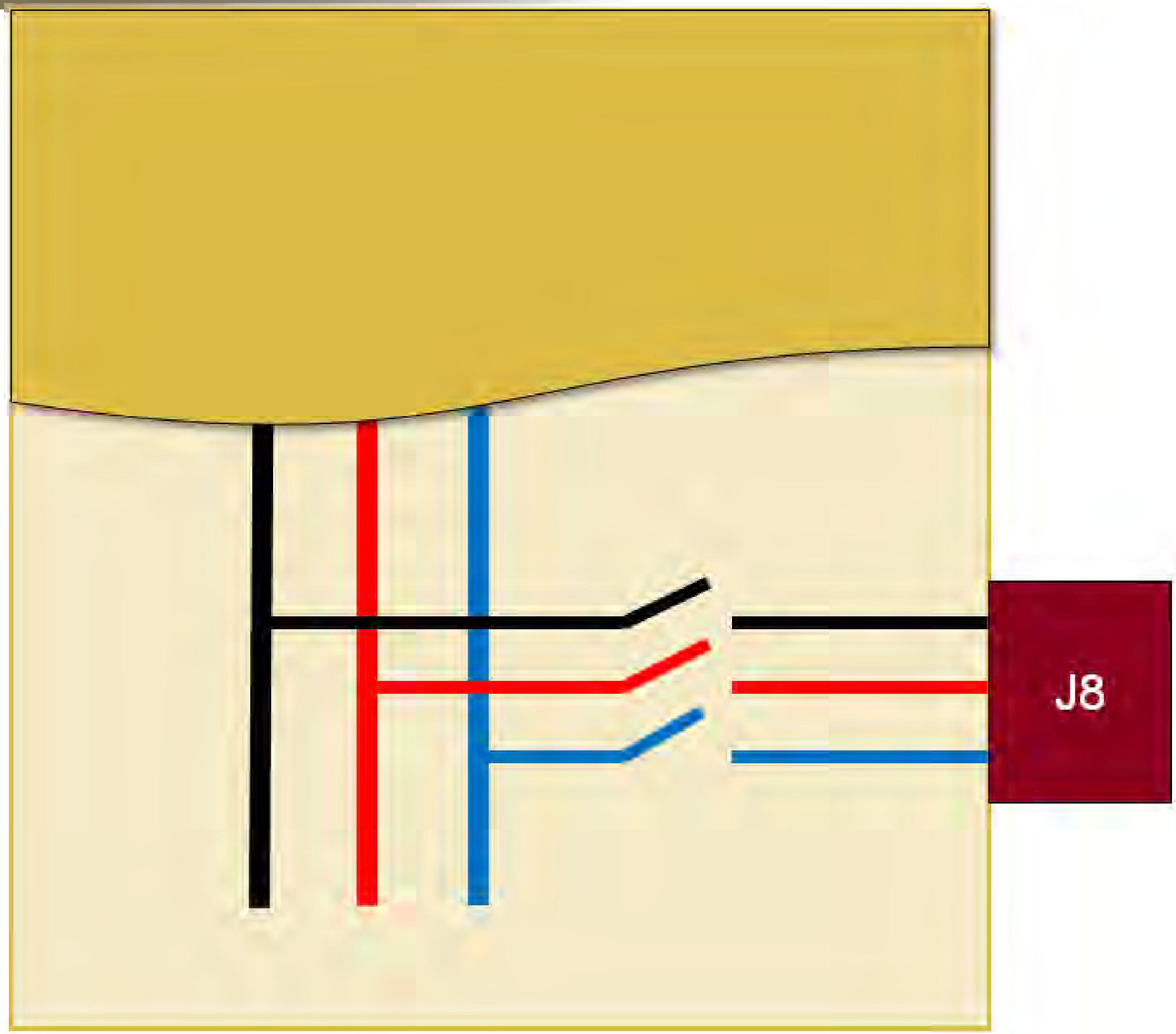


M40
20A, 1ϕ
Outputs
A
J13
B
J11
C
J9
A
J7
B
J5
C
J3
J14
A
J12
B
J10
C
J8
A
J6
B
J4
C
20A, 1ϕ
Outputs
40A, 3ϕ
Input
A
B
C
J1
J2
A
B
C
40A, 3ϕ
Output

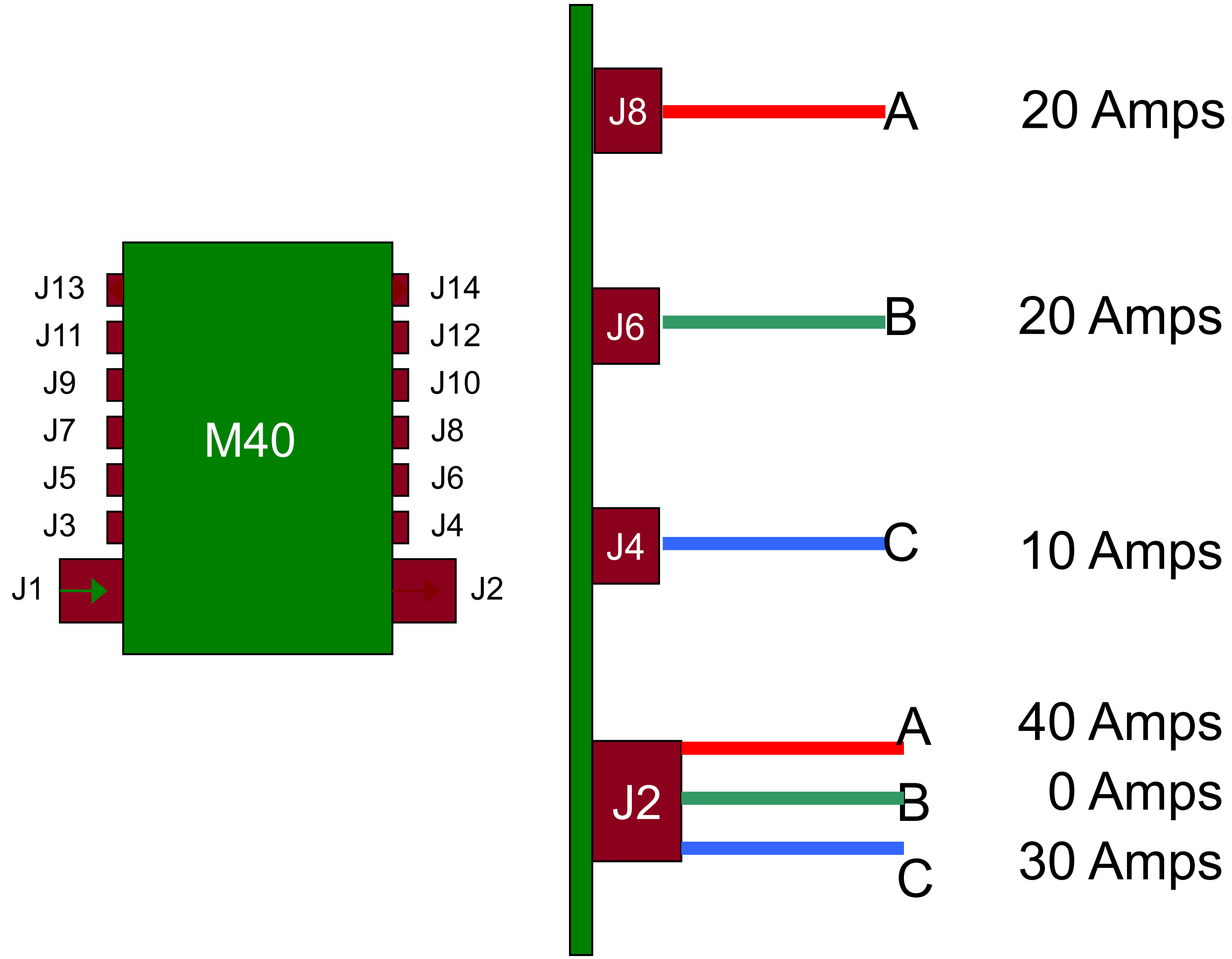
IPMDS 40


IPMDS
40
20A, 1ϕ
Outputs
20A, 1ϕ
Outputs
A
J13
B
J11
C
J9
A
J7
B
J5
C
J3
J14
A
J12
B
J10
C
J8
A
J6
B
J4
C
40A, 3ϕ
Input
A
B
C
J1
J2
A
B
C
40A, 3ϕ
Output

IPMDS 40



Improper Load Balance



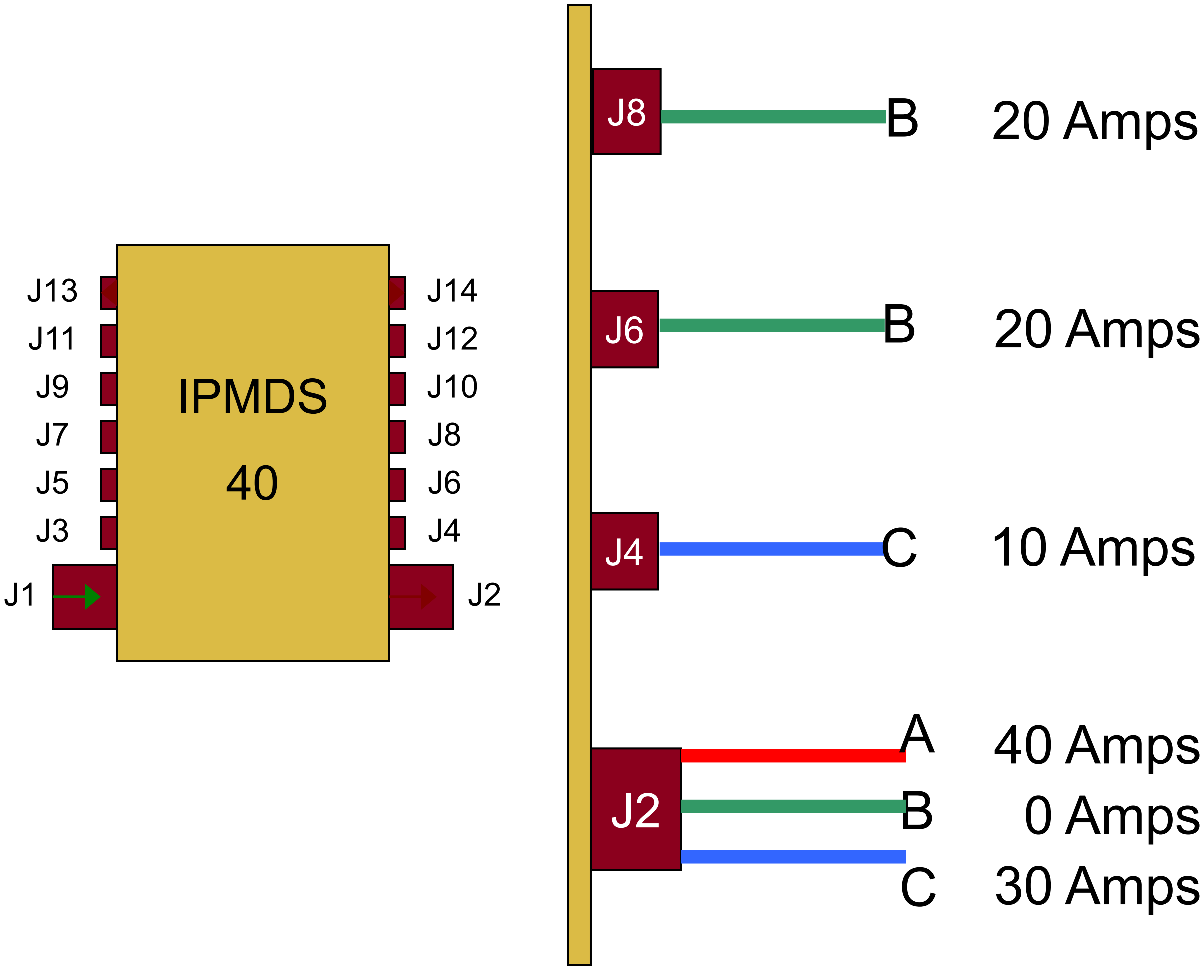
Unbalanced Load

A - 60 Amps
B - 20 Amps
C - 40 Amps
120 Amps

Exceeds Phase A, 40 amp current limit

→ **Trip Breaker**

Automatic Load Balance



Balanced Load

A - 40 Amps
B - 40 Amps
C - 40 Amps
120 Amps

IPMDS switches J8 from phase A to B and avoids circuit breaker trip

→ **System Operational**

RDECOM

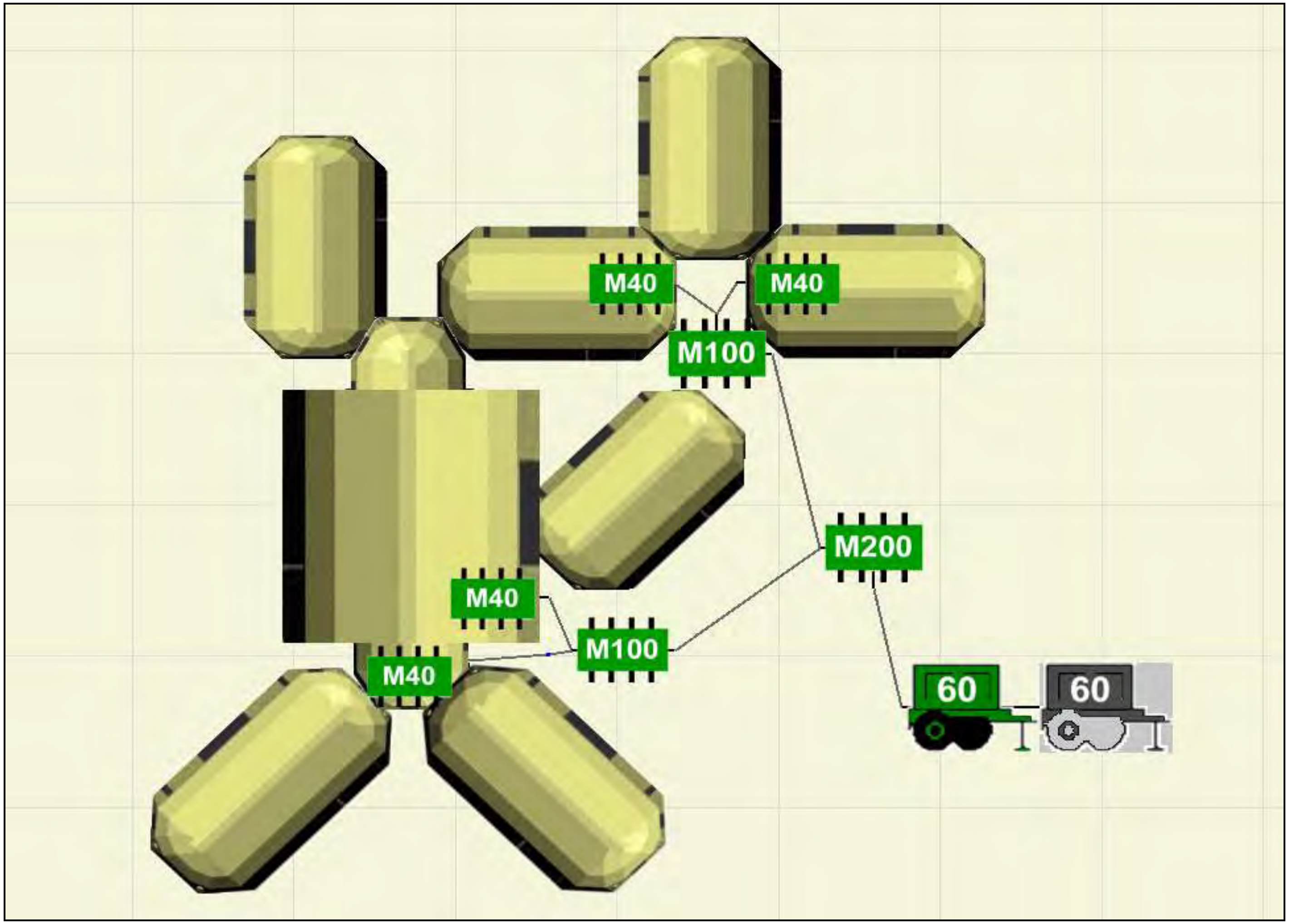
CERDEC
US ARMY – RDECOM

IPMDS Program

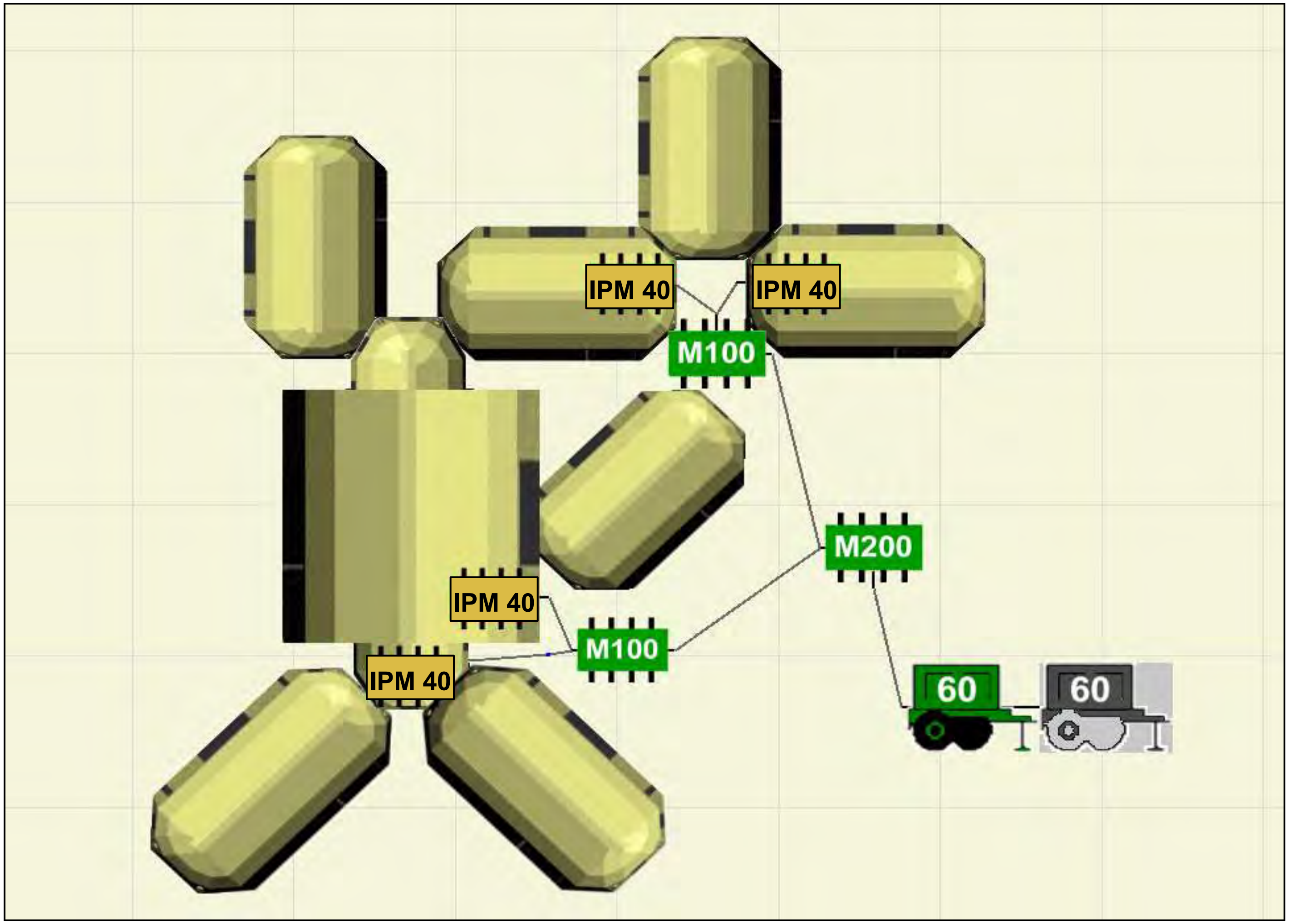
IPMDS Development

- IPMDS programs, managed by CERDEC and funded by PM-MEP and OSD
  - 200A
  - 100A and 40A
- Focus on IPMDS 40
  - Greater potential to improve the load balance
  - Less weight penalty

Example Main TOC with PDISE



Example Main TOC with IPMDS



IPMDS 40 Key Requirements

1. No larger or heavier than the M40 (4.9 cu. ft. and 55 lbs)
2. Compatible with PDISE (MIL-STD connectors)
3. Ruggedized for harsh environmental conditions
   – Operating: -50 to 135 F
   – Solar loading, sand/dust, rain, humidity, salt fog
4. Automatic load balancing
5. Switching time between phases < 18 ms

IPMDS 40 Key Requirements cont.

6. Provide a warning:
   – Voltage is out of safe operating range
   – Frequency is out of safe operating range
   – Input phase is missing
7. De-energize outputs:
   – Input phases are out of sequence
   – Break in ground conductor
8. Battleshort
9. Electronics bypass

IPMDS Benefits

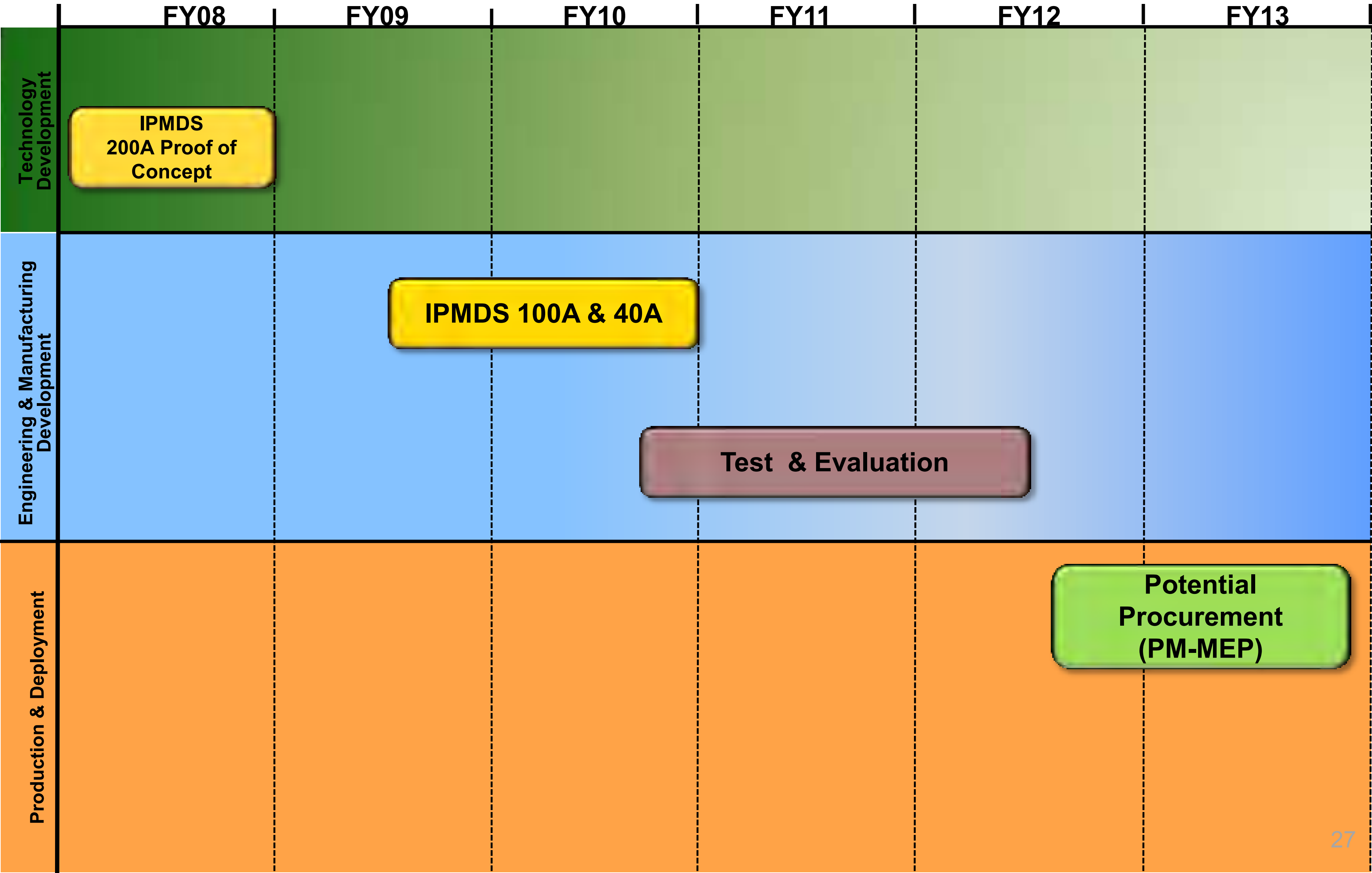
- *Availability of Power*
  - –Reduce time to establish effective power grid.
  - –Decrease circuit breaker trips.
  - –Decrease wear on generators.
    - •Reduce vibration
    - •Avoid additional heating of the stator core
  - →Maintain mission readiness.

IPMDS Benefits cont.

- *Increased Safety of Power Grid*
  - Warn user of improper setup
  - De-energize outputs in case of electrical hazard
  - →Reduce injury due to electrical hazards.
- Near-term solution.
  - →Increase capabilities sooner.

Schedule

IPMDS Schedule



Questions

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703-704-1848

Developing Hybrid and Sustainable Energy Solutions for the Increasing Power and Mobility Needs of the Warfighter

P. D. Madden, PE
CEO/General Manager
Energy Technologies, Inc.

T. D. Lowe, PhD
VP of Sales
Energy Technologies, Inc.

Wikipedia Definitions:

Hybrid power systems, like the name implies, combine two or more modes of electricity generation together.

Sustainable energy sources are most often regarded as including all renewable energy sources, such as hydroelectricity, solar energy, wind energy, wave power, geothermal energy, bioenergy, and tidal power.

"The U.S. Defense Department must change the way it uses energy on the battlefield as conflicts become longer and more expeditionary."

Deputy Defense Secretary William Lynn, April 26, 2011.

Traditional Deployed Power Sources

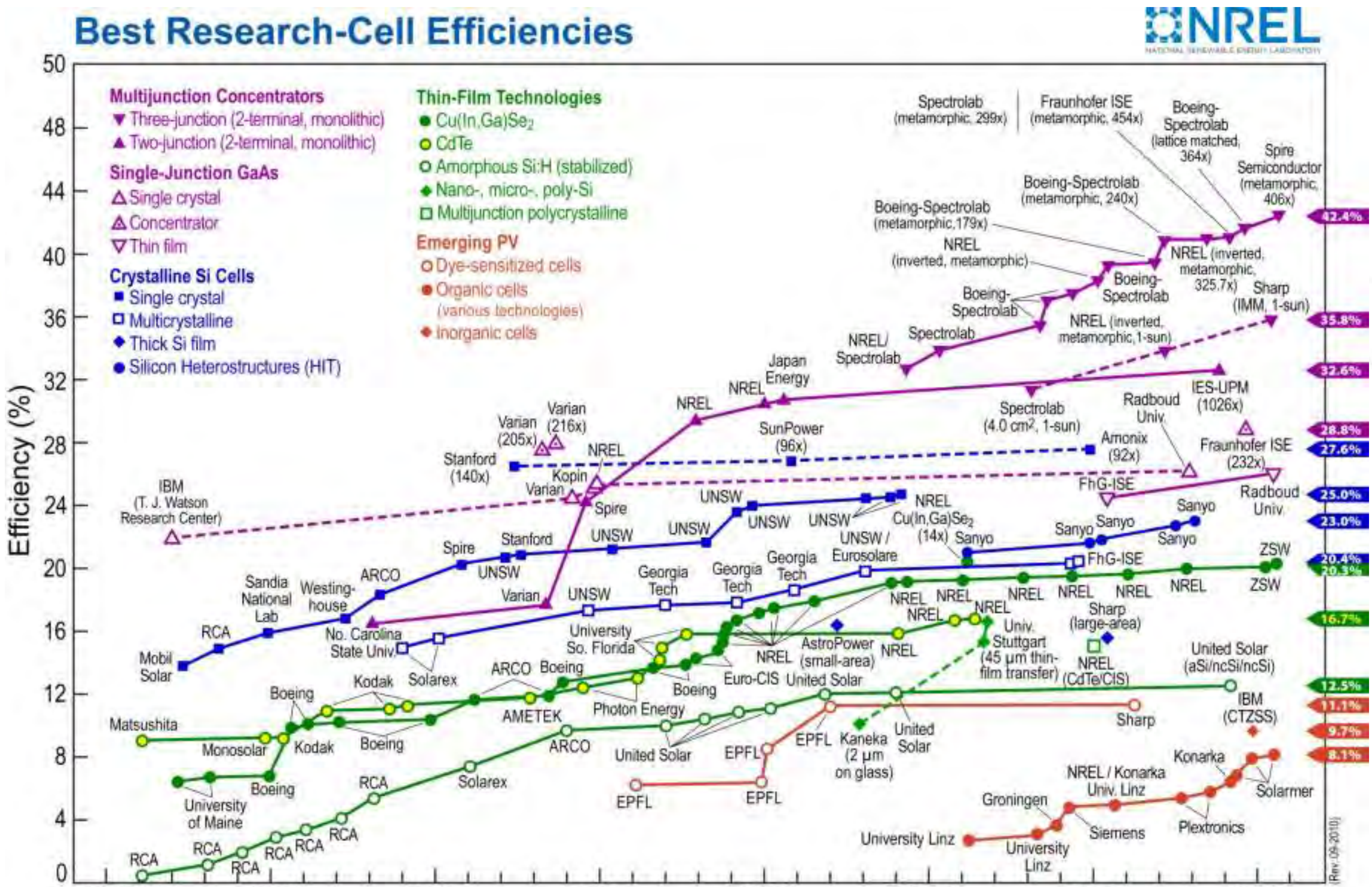
- Legacy Diesel Generators
- Tactical Quiet Generators
- Newer Intelligent Generators

Deployable Renewable Energy Sources

- Solar Energy
- Wind Energy
- Fuel Cells

Typical Types of Solar Panels

- Rigid Panels
  - Monocrystalline
  - Polycrystalline
- Flexible Panels
  - Amorphous Silicon (a-Si)
  - Copper Indium Gallium Selenide (CIGS)
  - Cadmium Telluride (CdTe)

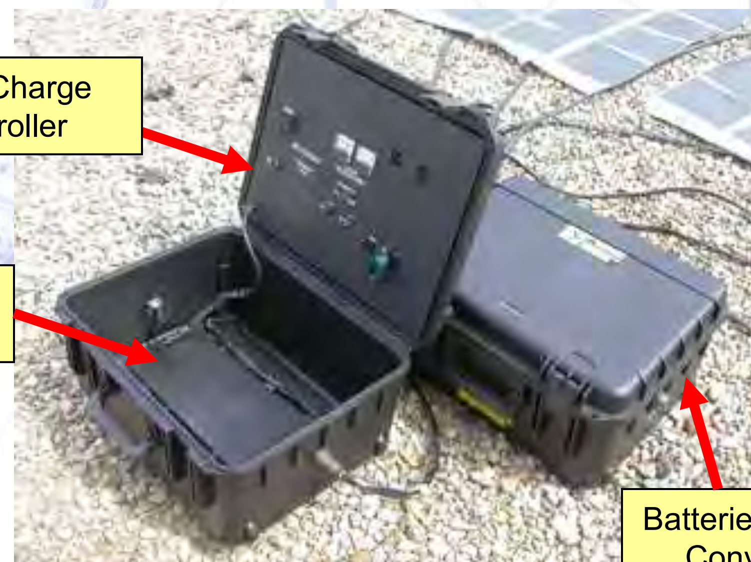

Best Research-Cell Efficiencies
NREL
Multijunction Concentrators
Three-junction (2-terminal, monolithic)
Two-junction (2-terminal, monolithic)
Single-Junction GaAs
Single crystal
Concentrator
Thin film
Crystalline Si Cells
Single crystal
Multicrystalline
Thick Si film
Silicon Heterostructures (HIT)
Thin-Film Technologies
Cu(In,Ga)Se2
CdTe
Amorphous Si:H (stabilized)
Nano-, micro-, poly-Si
Multijunction polycrystalline
Emerging PV
Dye-sensitized cells
Organic cells
(various technologies)
Inorganic cells
Efficiency (%)
50
48
44
40
36
32
28
24
20
16
12
8
4
0
1975
1980
1985
1990
1995
2000
2005
2010
42.4%
35.8%
32.6%
28.8%
27.6%
25.0%
23.0%
20.4%
20.3%
16.7%
12.5%
11.1%
9.7%
8.1%
Spectrolab (metamorphic, 299x)
Fraunhofer ISE (metamorphic, 454x)
Boeing-Spectrolab (lattice matched, 364x)
Spire Semiconductor (metamorphic, 406x)
Boeing-Spectrolab (metamorphic, 240x)
Boeing-Spectrolab (metamorphic,179x)
NREL (inverted, metamorphic)
NREL (inverted, metamorphic, 325.7x)
Sharp (IMM, 1-sun)
NREL (inverted, metamorphic,1-sun)
Spectrolab (4.0 cm², 1-sun)
IES-UPM (1026x)
Radboud Univ.
Amonix (92x)
Fraunhofer ISE (232x)
FhG-ISE
Radboud Univ.
Stanford (140x)
Varian (205x)
Varian (216x)
SunPower (96x)
Japan Energy
IBM (T. J. Watson Research Center)
Mobil Solar
Matsushita
Monosolar
University of Maine
Sandia National Lab
Westing-house
No. Carolina State Univ.
University So. Florida
AstroPower (small-area)
Euro-CIS
United Solar
Univ. Stuttgart (45 µm thin-film transfer)
Sharp (large-area)
NREL (CdTe/CIS)
United Solar (aSi/ncSi/ncSi)
IBM (CTZSS)
Kaneka (2 µm on glass)
EPFL
Sharp
Konarka
NREL / Konarka Univ. Linz
Solarmer
Groningen
Siemens
Plextronics
University Linz
Rev. 09-2010

Flexible Solar Panels

- Most practical for deployable applications
- 1 – 4500 watt panels
- Much lighter weight than rigid panels
- Less prone to damage vs. rigid panels
- Flexible and can be folded at seams
- Durable waterproof & UV resistant
- Operating temperature range of -40° to 80°C
- Complies with environmental Mil-Std 810F
- Most can operate with punctures & holes at reduced power


Ten Panel
Solar
Power
System


TacticalPower
Solar Panel
J-Box

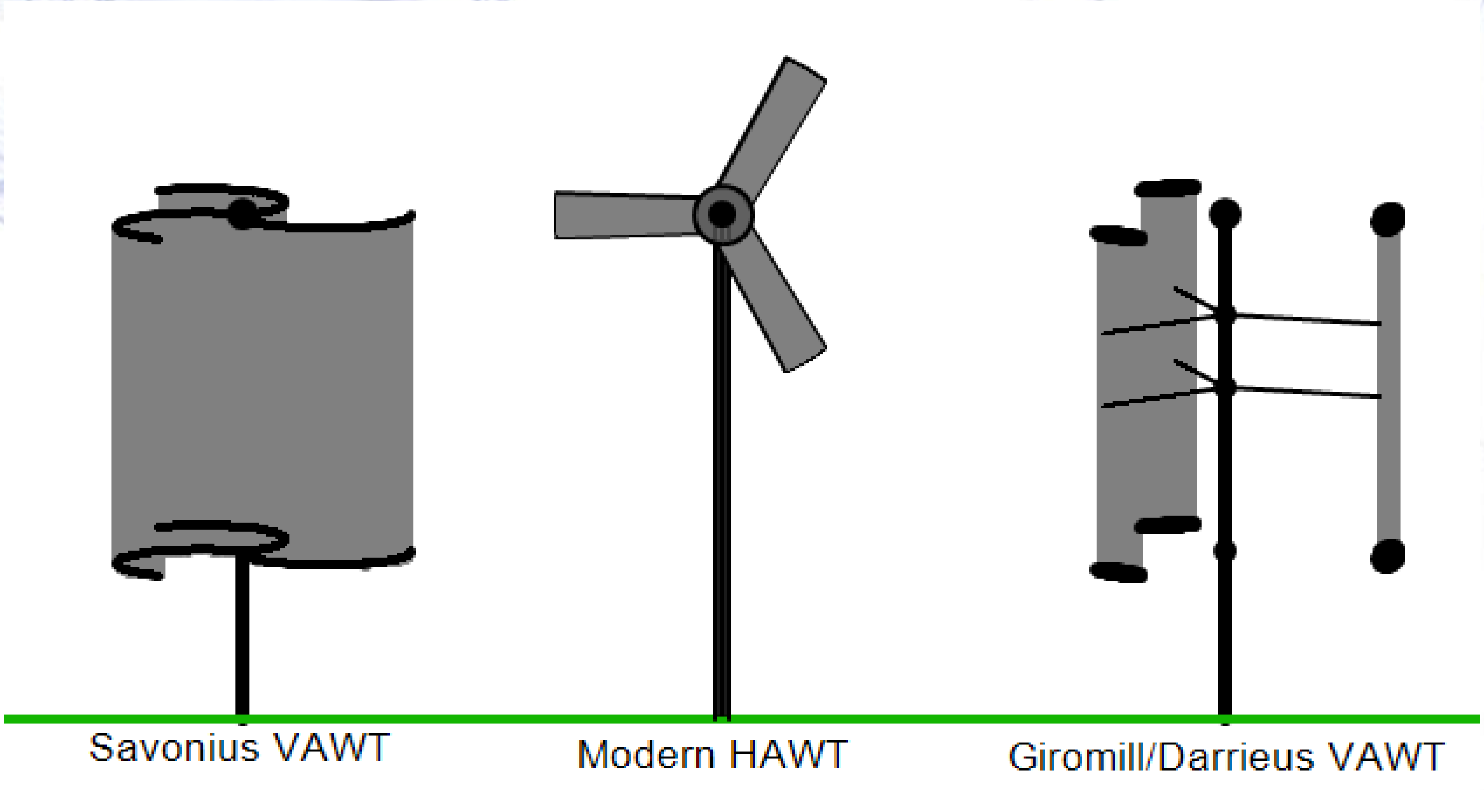

Solar Charge
Controller
Solar Panel
Storage
Batteries &Power
Conversion

Solar Fly System Set Up

Typical Types of Wind Turbines

- Horizontal Axis Wind Turbine (HAWT)
- Vertical Axis Wind Turbine (VAWT)

Typical Types of Wind Turbines



Transportable Wind Turbines

- Currently, HAWT are the most practical for deployment
- Compact size 3 or 5-blade turbines produce up to 3500 Watts
- Most models weigh 50 lbs. or less
- Quieter than typical wind turbines
- Available carbon fiber telescoping masts are strong yet light weight.
- The entire system can be easily setup
  by two people in only a few minutes.

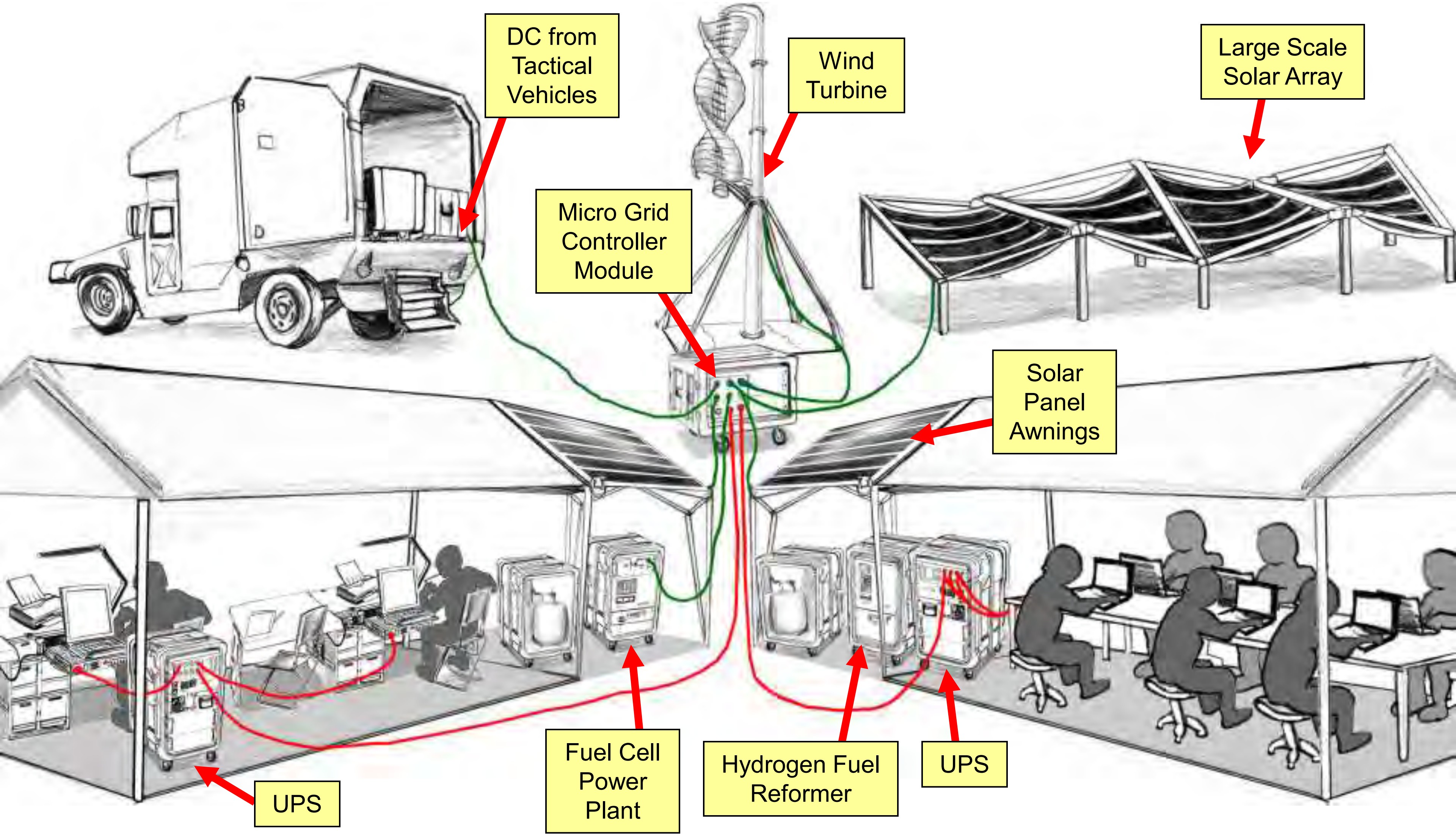
Typical Types of Fuel Cells

- Polymer Electrolyte Membrane (PEMFC)
- Direct methanol (DMFC)
- Alkaline (AFC)
- Phosphoric Acid (PAFC)
- Solid Oxide (SOFC)
- Molten Carbonate (MCFC)

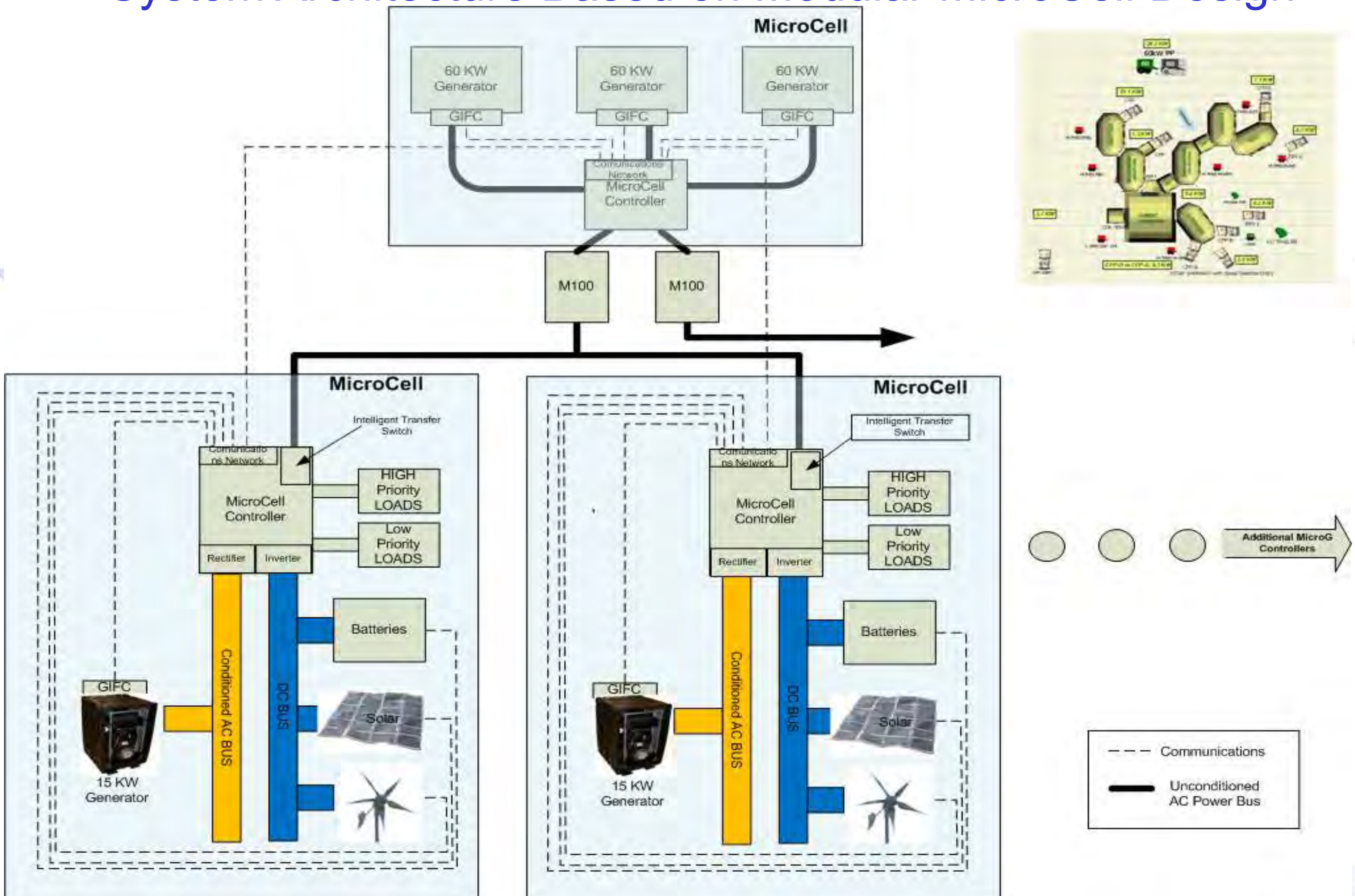
Alkaline Fuel Cell Power Plant

- Well suited for replacing 1-15 kW diesel fueled generators in tactical applications
- Internal Metal Hydride Fuel Cell stack provides hours of continuous runtime at full load
- Does not require expensive platinum
- Instant start capability vs. delayed
- More rugged than other fuel cells
- Smaller than other FC for same rating
- Intrinsic energy storage
- Operates in lower temperatures

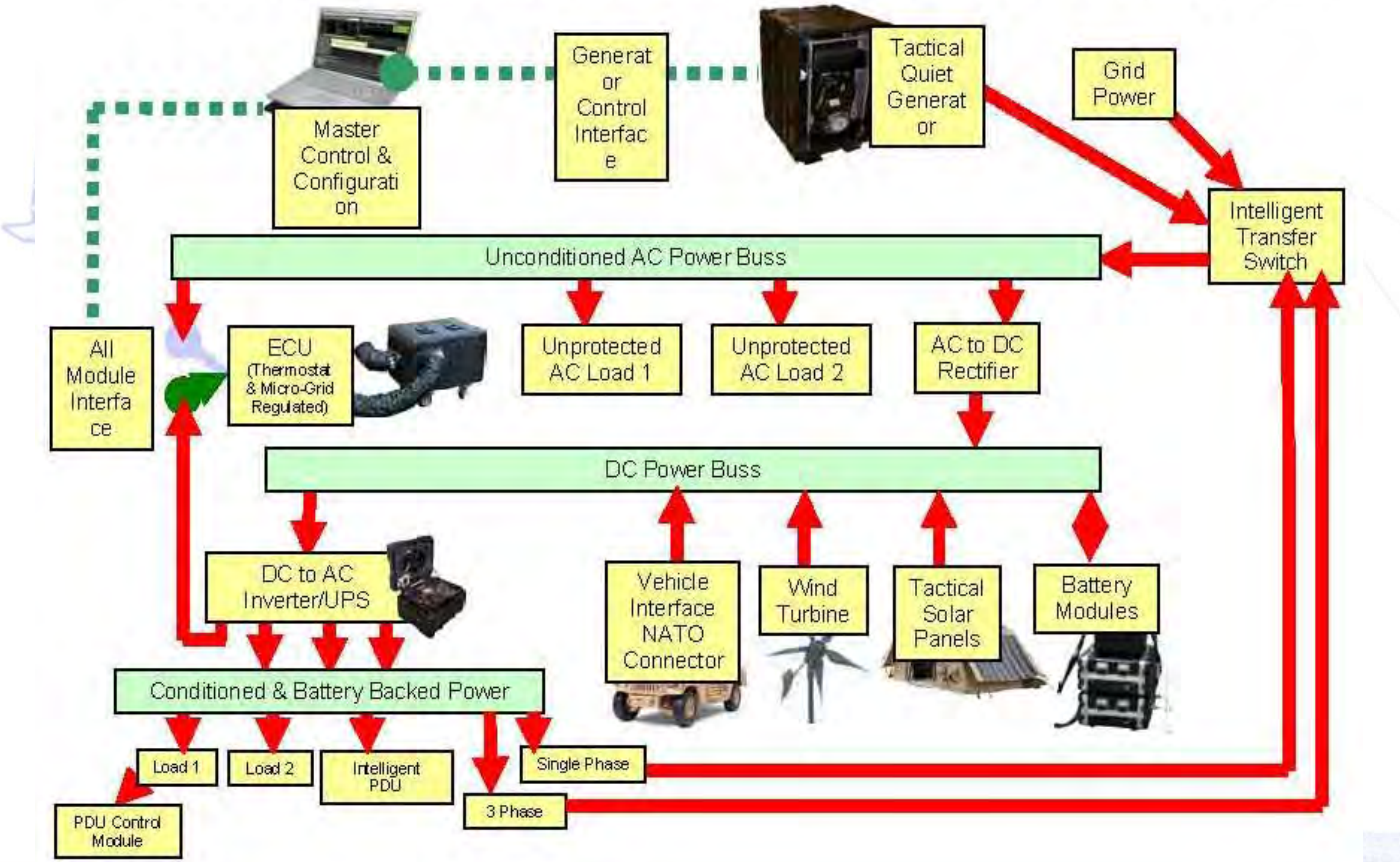
Hybrid Powered Base



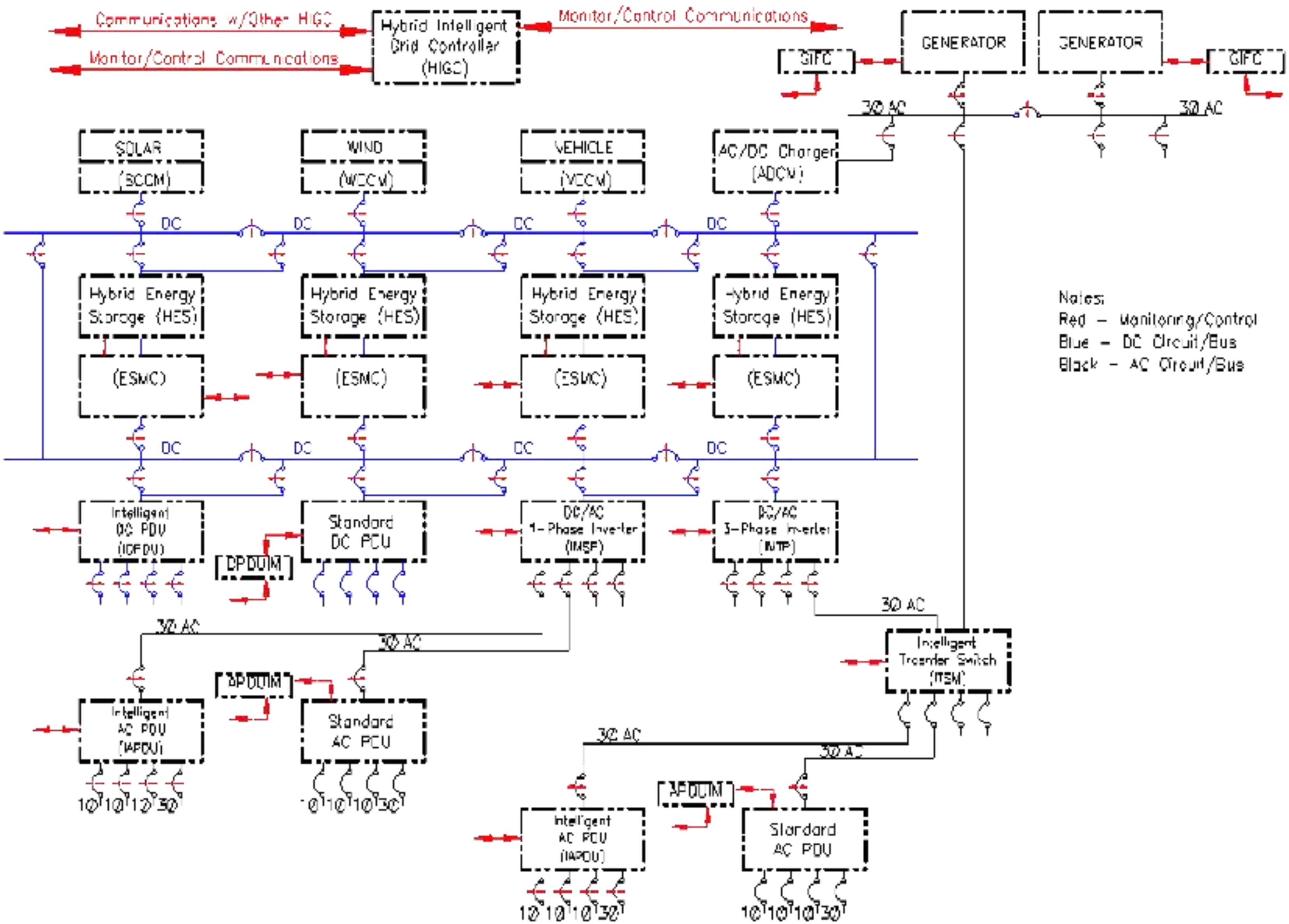
System Architecture Based on Modular MicroCell Design



Intelligent MicroCell Power System Architecture



System Electrical and Control Interface Diagram



The system is comprised of the following modules:

- Master Control & Configuration Display Module (MCCDM)
- Hybrid Intelligent Micro Grid Controller (HIGC)
- Generator Interface/Control Module (GIFC)
- Intelligent AC Transfer Switch Module (ITSM)
- Solar DC Charge Controller (SCCM)
- Wind Generator DC Charge Controller (WCCM)
- Vehicle NATO Connector Interface DC Charge Controller Module (VCCM)

The system is comprised of the following modules: (continued)

- Energy Storage Module & Controller (ESMC) Li-Ion Based
- Intelligent AC Power Distribution Unit (IAPDU)
- AC PDU Interface Module (APDUIM)
- Intelligent DC Power Distribution Unit (IDPDU)
- DC PDU Interface Module (DPDUIM)
- DC to AC Inverter Module Single Phase (IMSP)
- DC to AC Inverter Module Three Phase (IMTP)
- AC to DC Charger Module (ADCM)

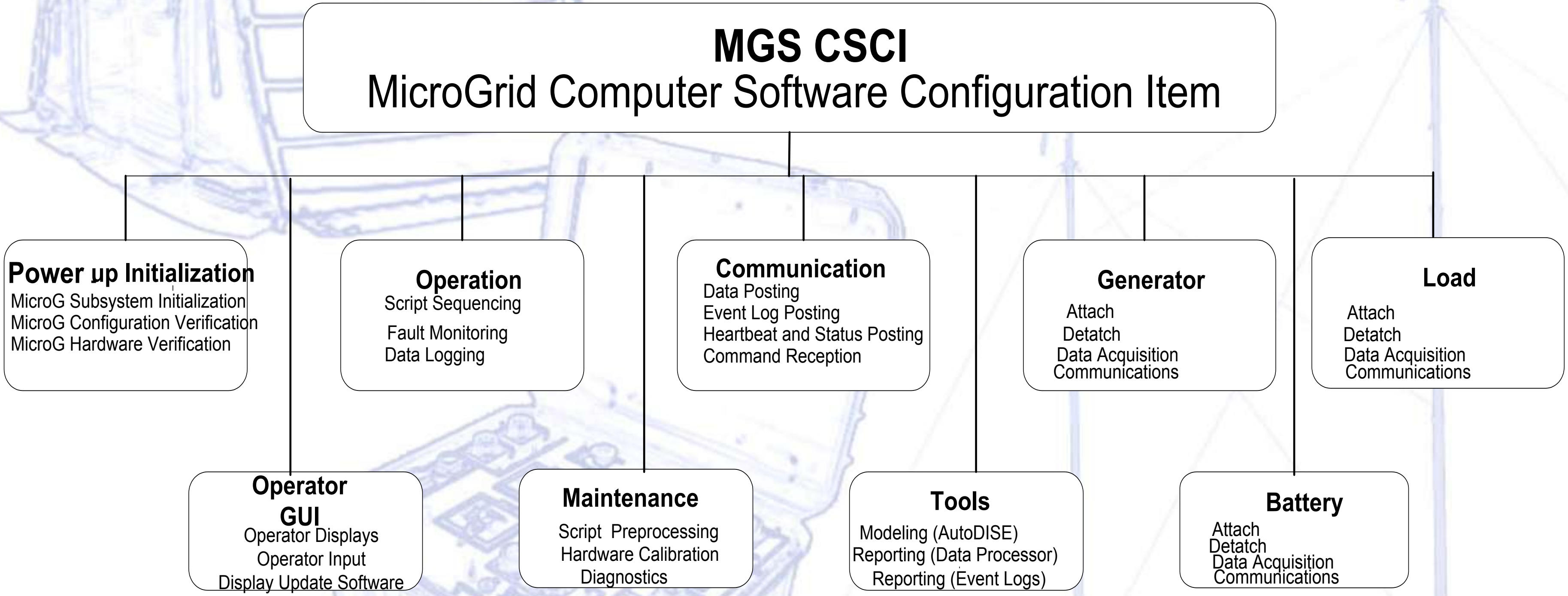
Master Control & Configuration Display Module (MCCDM)

- Main interface to the system
- Tactical based Laptop computer or a larger Desk Top depending on system size.
- Menu based human interface and configuration data management.
- Allows specific configurations for power generation, load balancing, automated module fault restoration and system optimization.
- Data element modules contain and support multi-level configuration access protection.

This module has three basic functions:

1. Configuration Set Up
2. Monitoring
3. Performance and Data Gathering

Micro Grid Computer System Software Architecture



N2 Chart with Micro Grid States and Modes

State	Mode	Submode							
Non-Operational	Transport	**System OFF**	Unload						
	Emplaced	Load	**System SetUp**	Power On		Command Maintenance			
			Power Off	**Initialization**	System Verification Enabled	Command Maintenance			
Operational	Standby		Command Power Off	Command Reboot	**Standby**	Command Maintenance	Command Battle Short	Command Online	
					Command Standby	**Maintenance**	Command Battle Short	Command Online	ABORT Button
	Grid Control				Command Standby		**Battle Short**	Command Online	ABORT Button
					Command Standby			**Grid Control Online**	System Fault ABORT Button
					Command Standby				**Grid Control ABORT**

Hybrid Intelligent Grid Controller (HIGC)

- Master controller of the configured system or sub-system depending on system size and complexity
- Modular and can be configured from 15 kW to over 750 kW based on application
- Module takes the input power resource and distributes and controls as configured without any dependence on additional controller modules
- Interface to support setting up a configuration via a portable device when the master control and configuration display module is not configured in small applications
- Default configuration/operations reside in this module for all battle short algorithmic functions and actions

Generator Interface/Control Module (GIFC)

- Configured to allow interface to the range of size generators
- Interprets the system commands to the control functions of the generator for starting, paralleling and status functions
- Capability to monitor consumables such as fuel and oil levels
- Module will take and execute all commands from the HIGC based on the configuration settings and shut down requirements as defined by the algorithmic functions of the system
- Interface module will also contain a fall back or battle short capability as these modules will be located on the generator and may not necessarily be located close to the HIGC

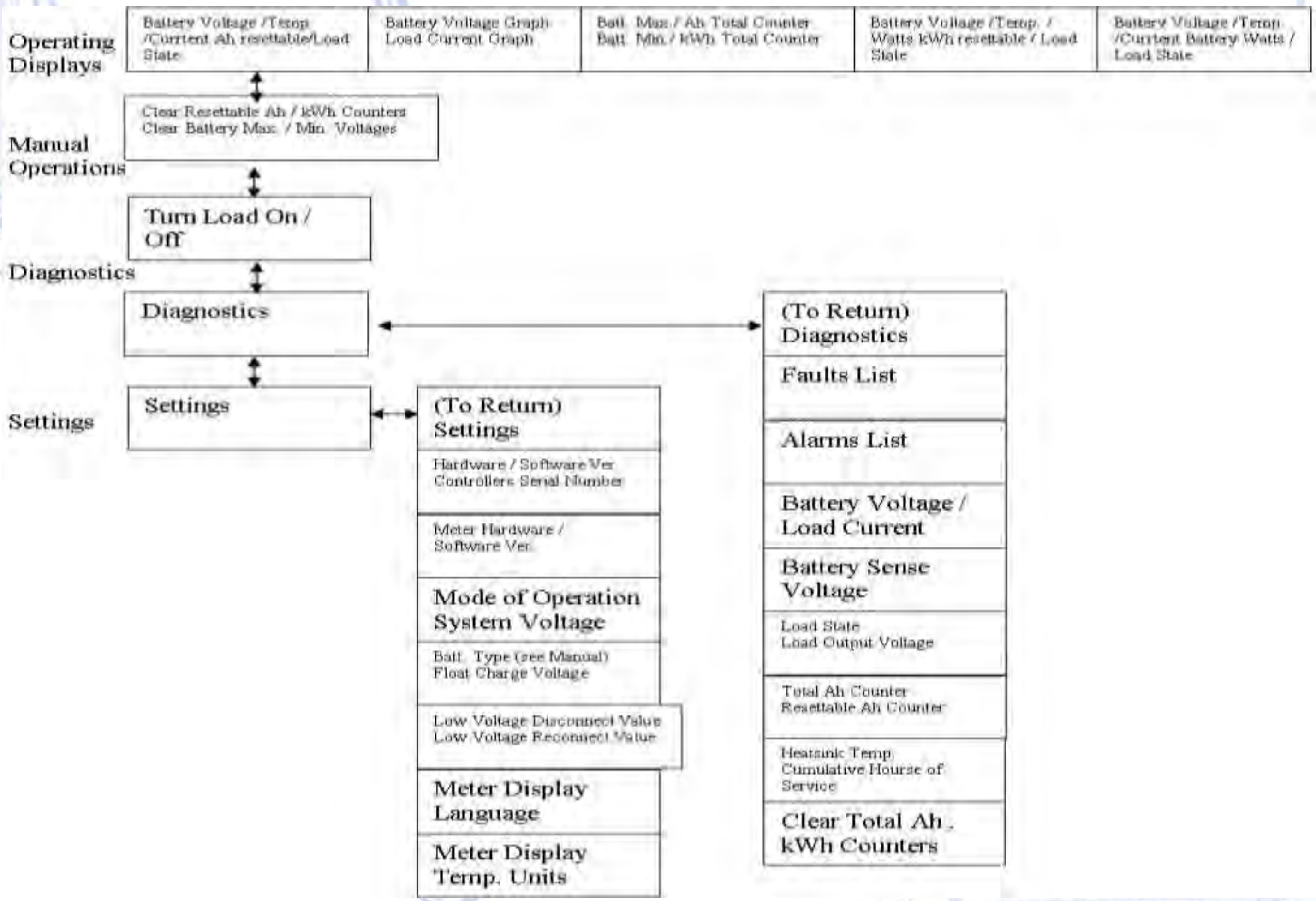
Intelligent AC Transfer Switch Module (ITSM)

- The Intelligent Transfer Switch Module interfaces to power generating sources and is configured in a fall back configuration that will allow the power to be distributed to the AC support bus
- ITSM has an intelligent interface that will operate based on the command requirements of the Hybrid Intelligent Grid Controller
- Upon loss of generating power, the HIGC can command the ITSM to disconnect from the generator and connect battery supplied inverters to the AC bus allowing continued operation of critical loads
- ITSM can support a local grid power sources and switch to the grid power to the AC support bus
- ITSM available in either 1-phase or 3-phase configurations

Solar DC Charge Controller (SCCM)

- Rated for 12, 24 or 48 VDC nominal solar panel input
- Ability for programmable or manual recovery
- Seven standard charging or load control configurations
- Intelligent interface to HIGC
- Continuous self-testing and fault notification
- Visual LED status indicators
- Remote battery sense capability
- Remote battery temperature sense

Solar Charge Controller basic software menu configuration supported both by the HIGC and manual mode:



Wind Generator DC Charge Controller (WCCM)

- Capable to support 12, 24 or 48 VDC battery configurations
- Ability for programmable or manual load limiting configuration
- Three standard charging or load control configurations
- Intelligent interface to HIGC
- Continuous self-testing and fault notification
- Visual LED status indicators
- Remote battery sense capability
- Remote battery temperature sense
- Integrated or remote excess power burn off modules
- Wind generator braking based on wind speed

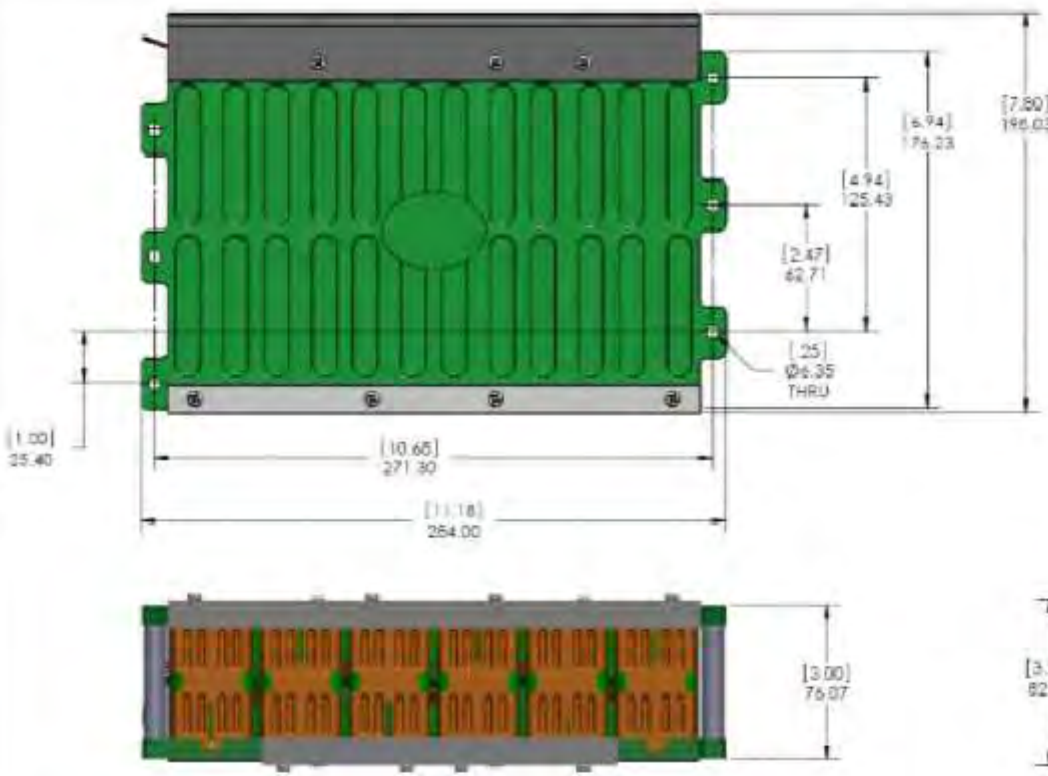
Vehicle NATO Connector Interface DC Charge Controller Module (VCCM)

- Capable to support 12, 24 or 48 VDC battery configurations
- Ability for programmable or manual recovery
- Four standard charging or load control configurations
- Intelligent interface to HIGC
- Visual LED status indicators
- Remote battery sense capability
- Remote battery temperature sense

Energy Storage Module & Controller (ESMC) Li-Ion Based

- 3X the Power Density of Standard Lead Acid Batteries
- 1/3 the Weight of Standard Batteries
- Individual Modules have Intelligent Software Monitoring and Control
- Interfaces with Hybrid Intelligent MicroGrid Controller

Individual Li-Ion Energy Storage Module



- 6 series cells, 8 parallel cells
- Weight: 12.75lb
- Length: 7.8”
- Width: 11.2”
- Height: 3.0”
- Voltage: 16.5-25.2VDC
- Capacity:
  - 780Wh (100% DOD),
  - 660 Wh (85% DOD)

Advanced Li-Ion vs. Traditional Li-Ion

= 4.5 of the BA-2590

135 Wh/kg
>2000 cycles

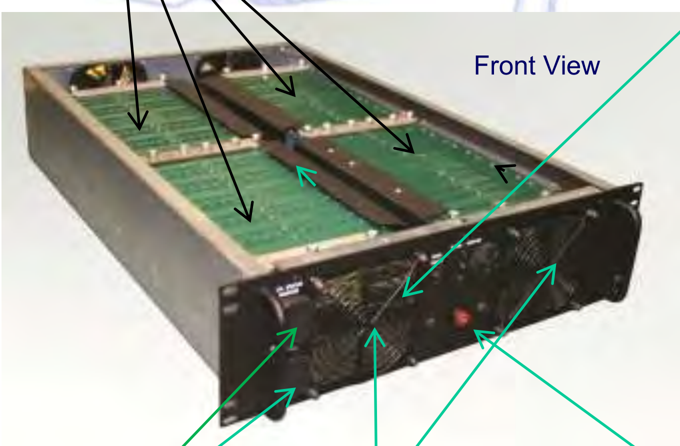
120 Wh/kg
>300 cycles

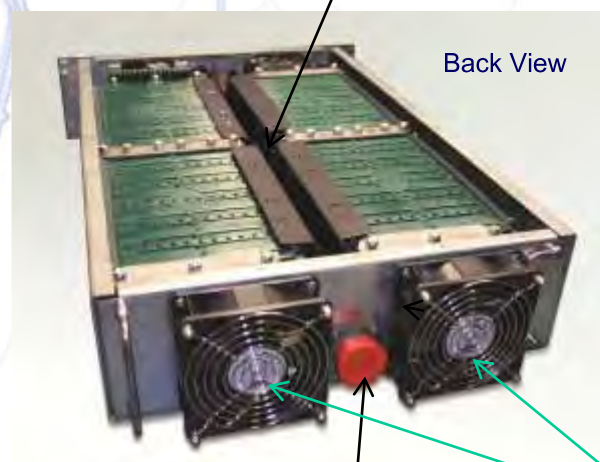
(4) Modules/3U = 3.12 kWh Capacity Or 21.84 kWh in a 21U Transit Case

Battery Modules

Front Panel Monitor (Visual/Audible Alarms)

BMS integrated electronics





Communication Ports

Air Intakes

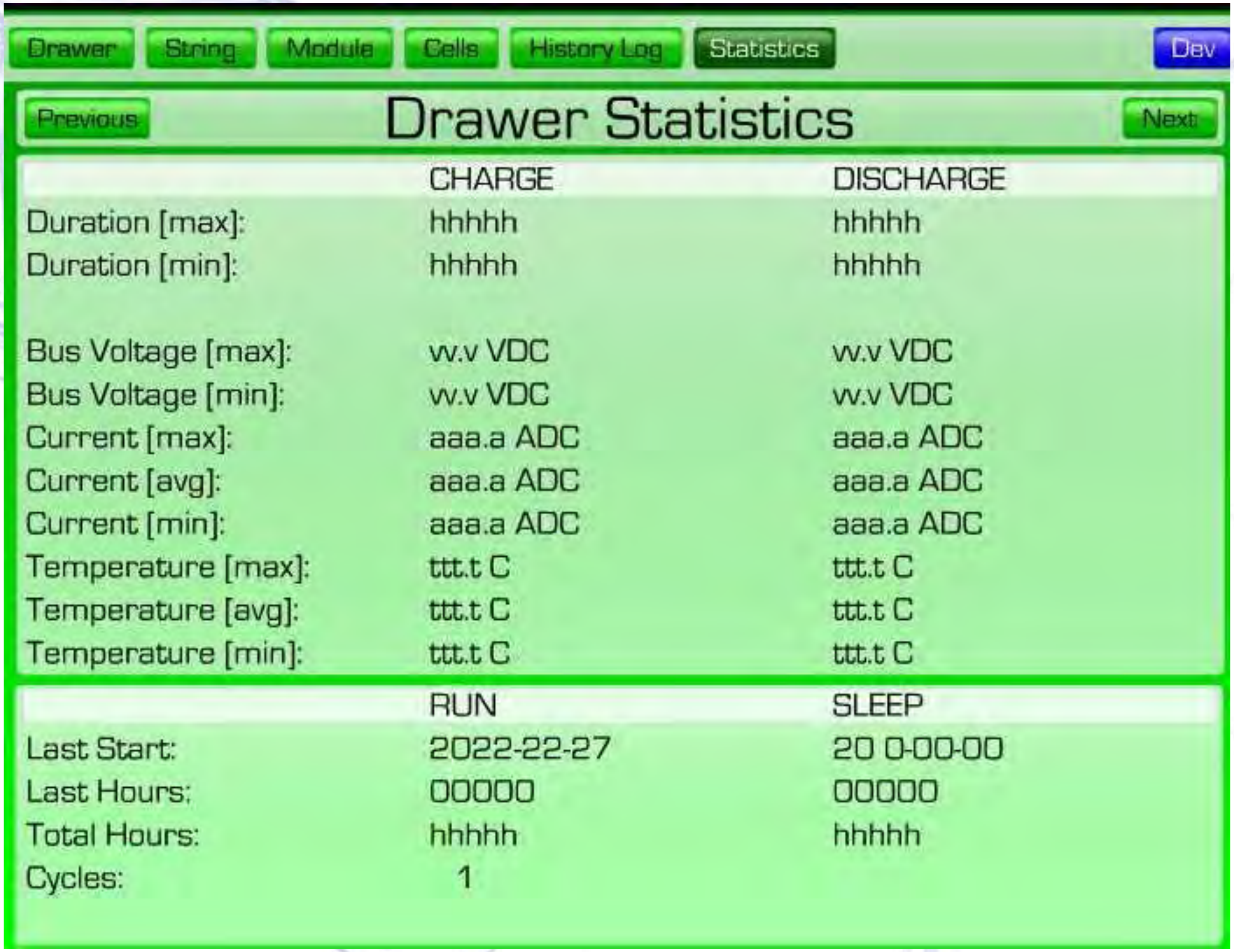
Output breaker

DC Cable connection

Cooling Fans

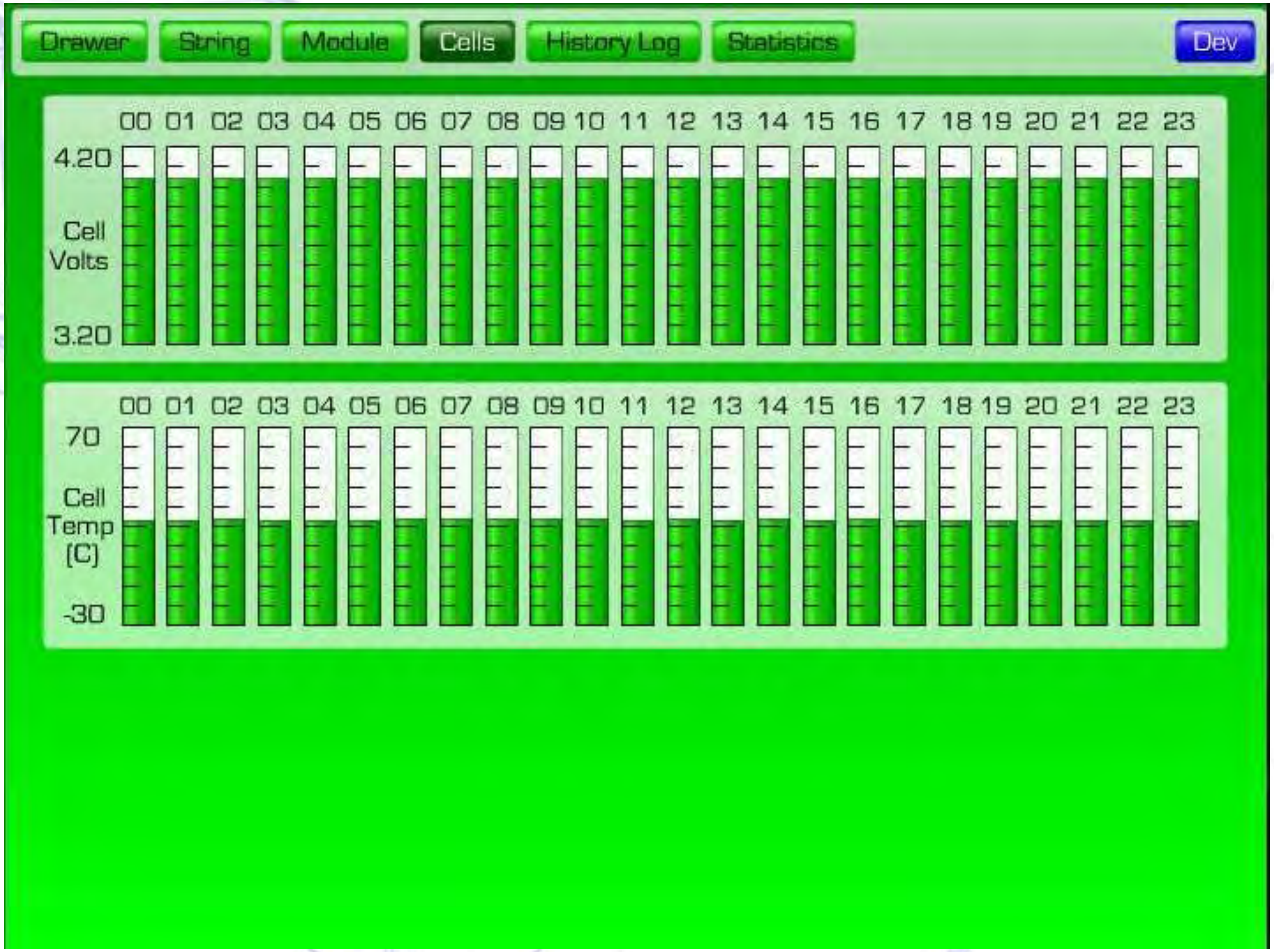
Li-Ion Interface – Drawer Level

Li-Ion Interface – Drawer Statistics



Li-Ion Interface – String Level

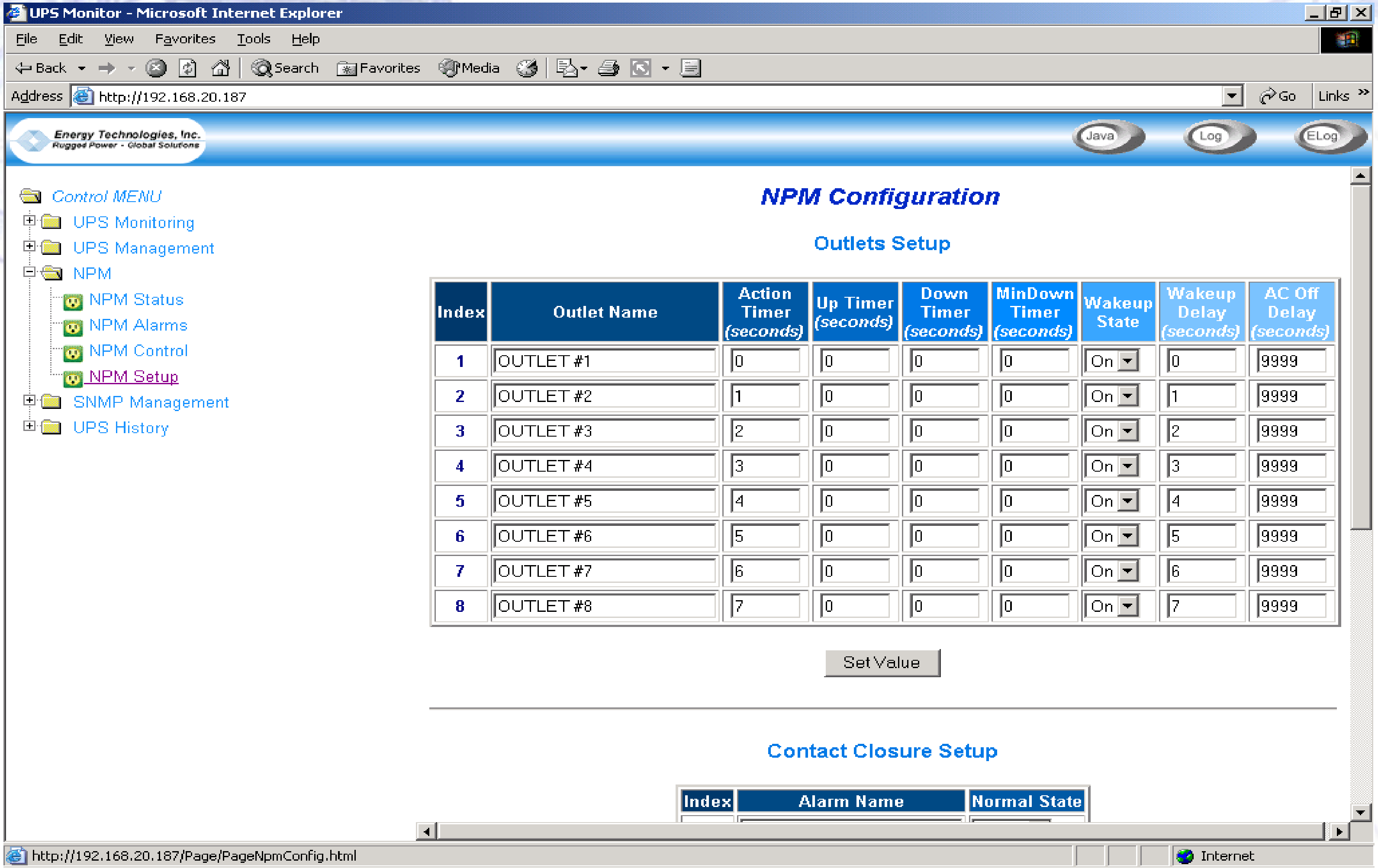
Li-Ion Interface – Cell Level



Intelligent AC Power Distribution Unit (IAPDU)
Intelligent DC Power Distribution Unit (IDPDU)

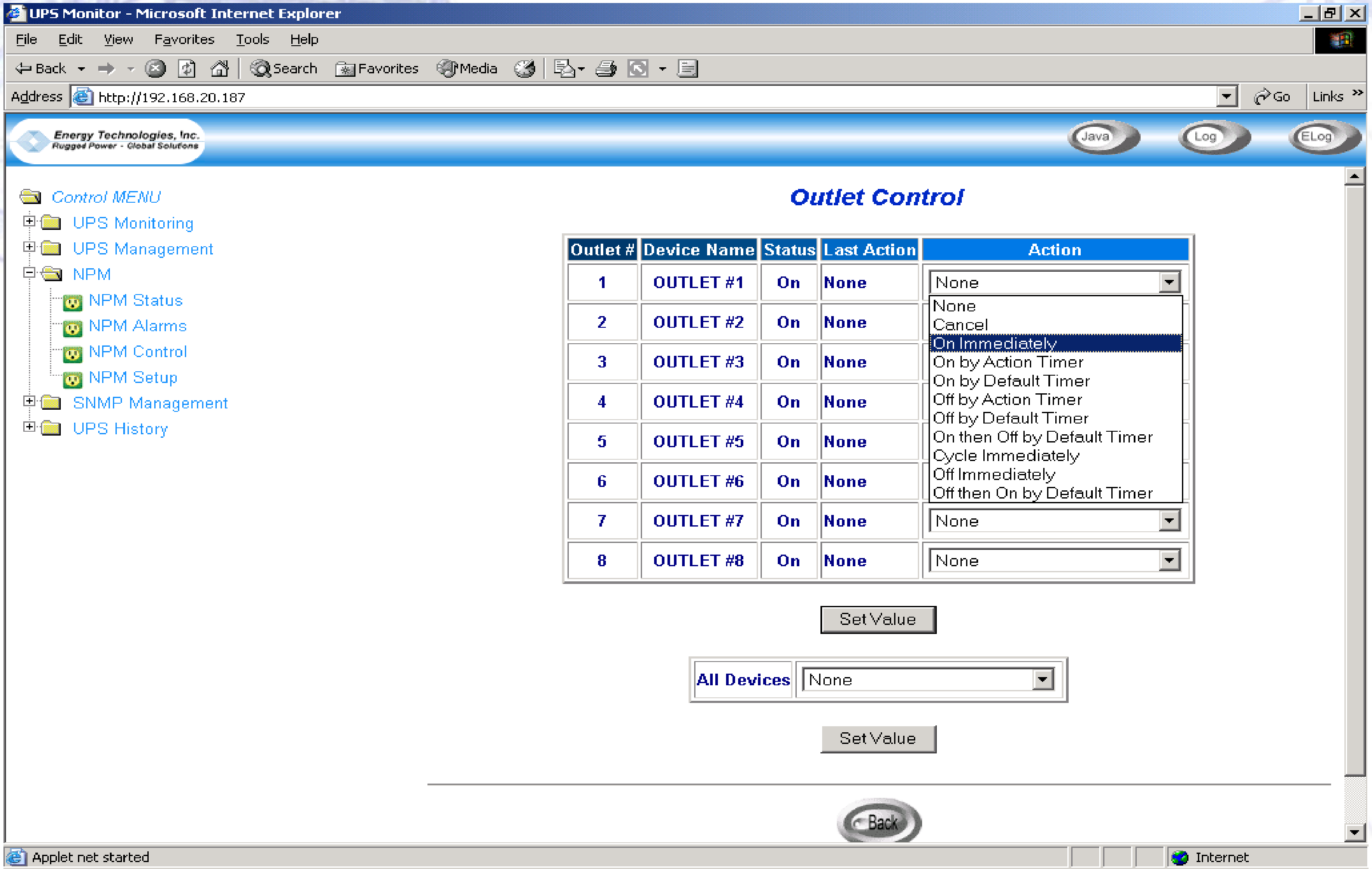
- Intelligent power distribution modules contain an interface and control module for the input and for each of the individual output connections
- Will operate based on the command requirements of the Hybrid Intelligent Grid Controller and/or manual mode
- Algorithms include assigned priority load shedding and sequential start-up and shut-down procedures
- AC version available in either 1-phase or 3-phase configurations
- Dual source input and various output configurations available

Screen shots examples of configuration setup elements:

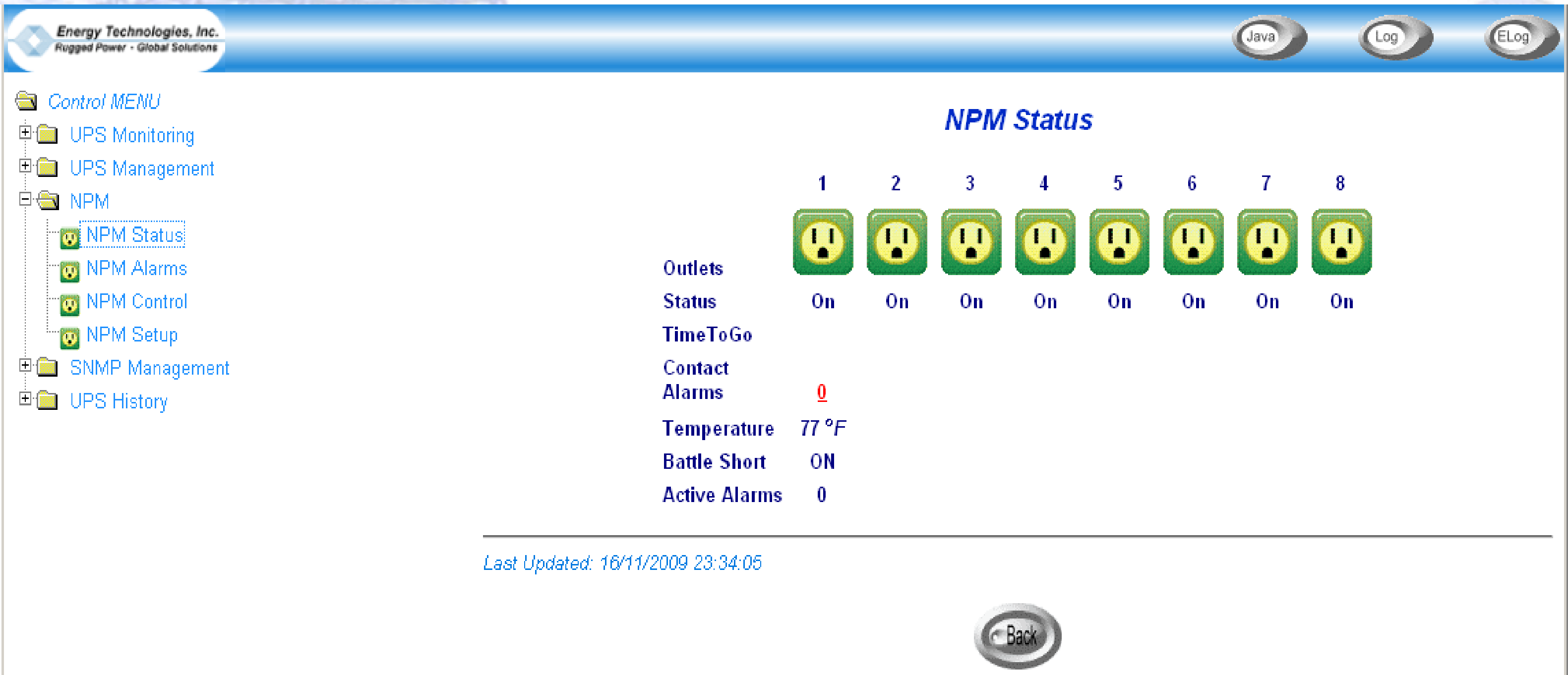


Index	Outlet Name	Action Timer (seconds)	Up Timer (seconds)	Down Timer (seconds)	MinDown Timer (seconds)	Wakeup State	Wakeup Delay (seconds)	AC Off Delay (seconds)
1	OUTLET #1	0	0	0	0	On	0	9999
2	OUTLET #2	1	0	0	0	On	1	9999
3	OUTLET #3	2	0	0	0	On	2	9999
4	OUTLET #4	3	0	0	0	On	3	9999
5	OUTLET #5	4	0	0	0	On	4	9999
6	OUTLET #6	5	0	0	0	On	5	9999
7	OUTLET #7	6	0	0	0	On	6	9999
8	OUTLET #8	7	0	0	0	On	7	9999

Screen shots examples of configuration setup elements:



The following screen is only one example of graphic display capabilities:

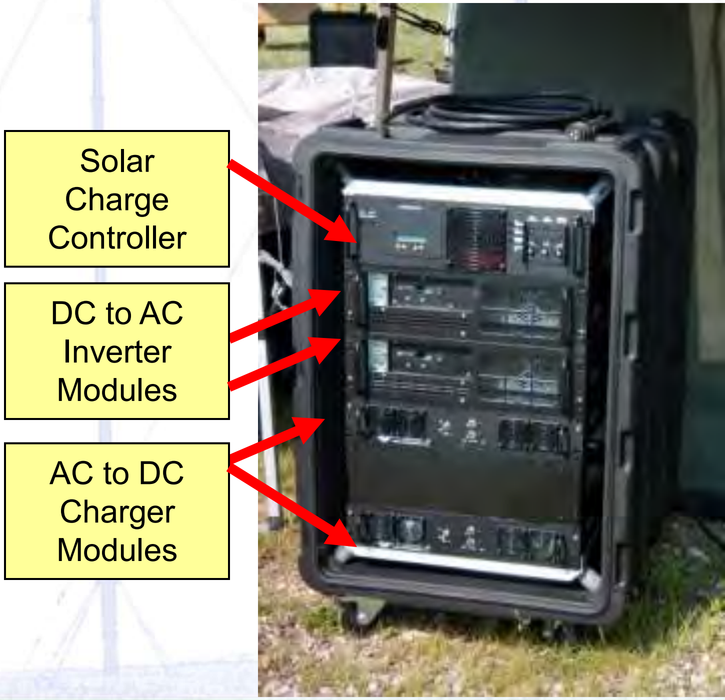


AC PDU Interface Module (APDUIM)
DC PDU Interface Module (DPDUIM)

- Intended to interface to existing PDU panels to allow the monitoring and control functions of the Intelligent PDU

DC to AC Inverter Module Single Phase (IMSP)
DC to AC Inverter Module Three Phase (IMTP)

- Available in either 1-phase or 3-phase output configurations
- Available in either 12, 24 or 48 VDC input configurations
- Monitoring and control interface to Hybrid Intelligent Grid Controller
- Pure, sinewave AC output



AC to DC Charger Module (ADCM)

- Available in either 1-phase or 3-phase input configurations
- Available in either 12, 24 or 48 VDC output configurations
- Monitoring and control interface to Hybrid Intelligent Grid Controller
- Configurable to allow for accelerated charge rates for the batteries
- Supports all battery technology charge curves

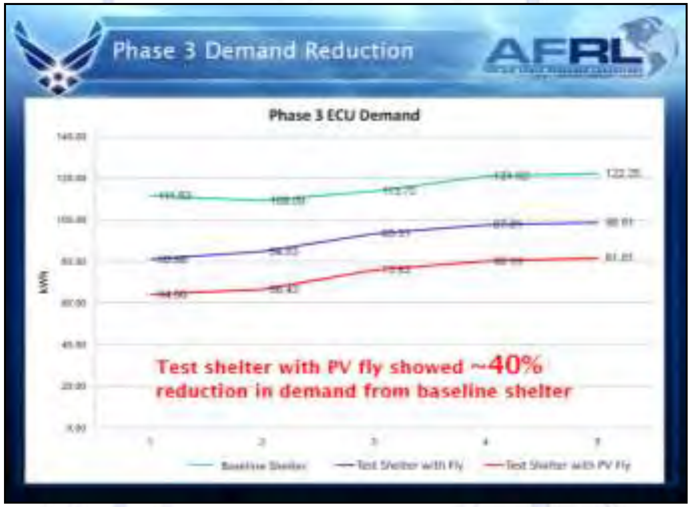
Hybrid Power Base

Demonstrations and Evaluation Testing

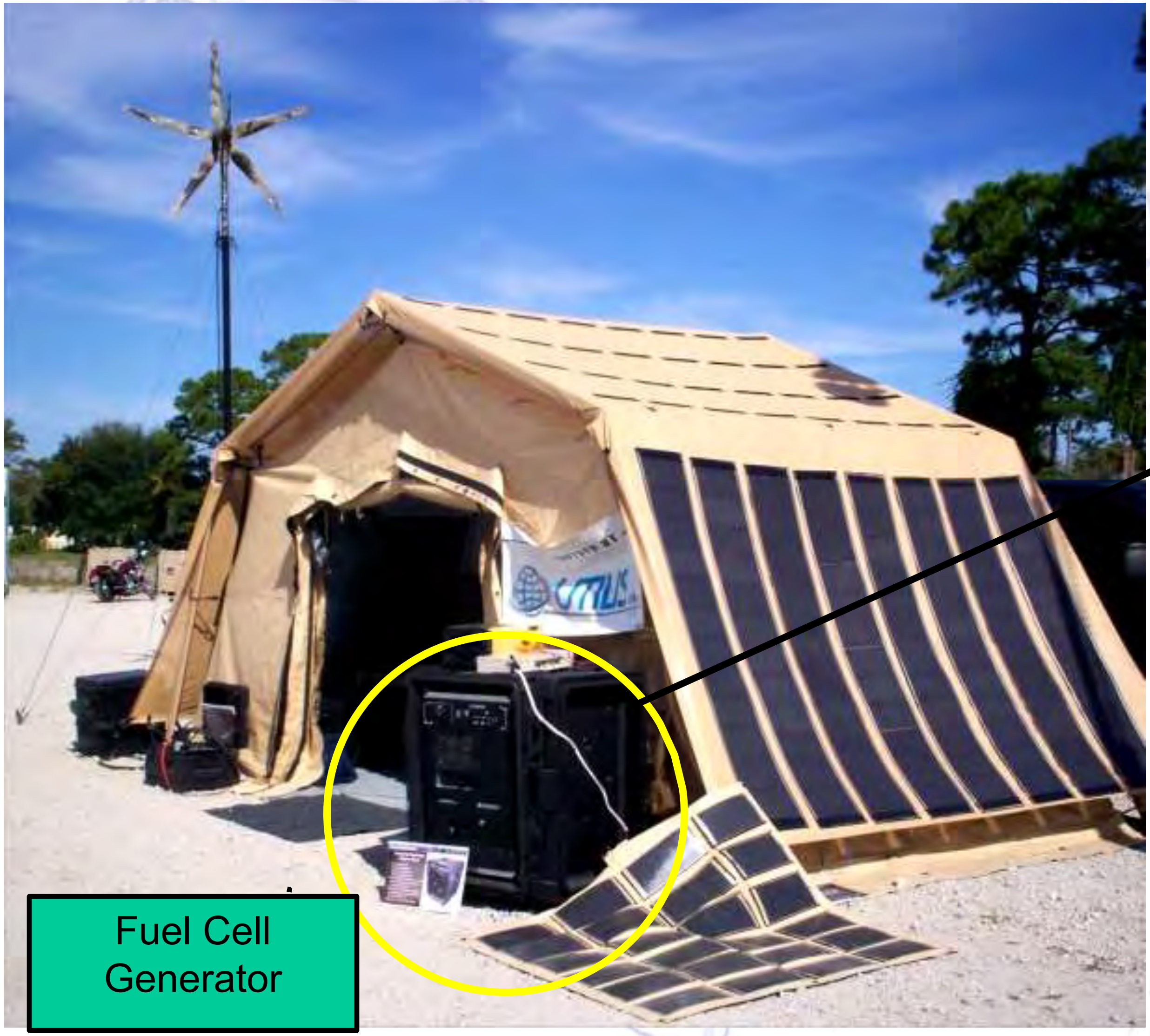
- AFRL Ft. Irwin
- Twenty-nine Palms ExFOB
- US Army Ft. Irwin
- US Air Force Tyndall AFB
- Southern Command
- Navy Crane

Advantages of a Solar Fly

- Fly shown to reduce ECU power consumption by 26% in AFRL tests
- Fly integrated with Photovoltaic (PV) cells generated > 4 kW
- Wind generators can provide 1.2 kW
- Participating in NetZero JCTD at Ft Irwin
- 40% reduction in demand with PV



Joint Committee on Tactical Shelters (JOCOTAS)



Twenty-nine Palms ExFOB System Set Up

US Army Ft. Irwin Solar Fly Set Up

Contact Information

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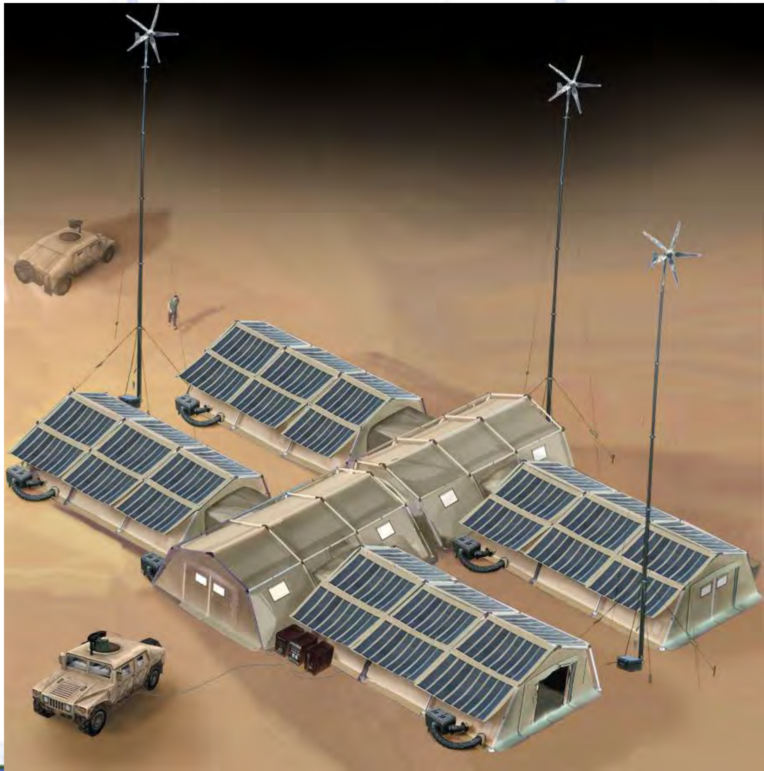
www.HybridEnergyTechnologies.com



Fuel Cell Technologies Program

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

2011 Joint Service Power Expo

May 3, 2011

Pete Devlin
Market Transformation and Intergovernmental Coordination Manager

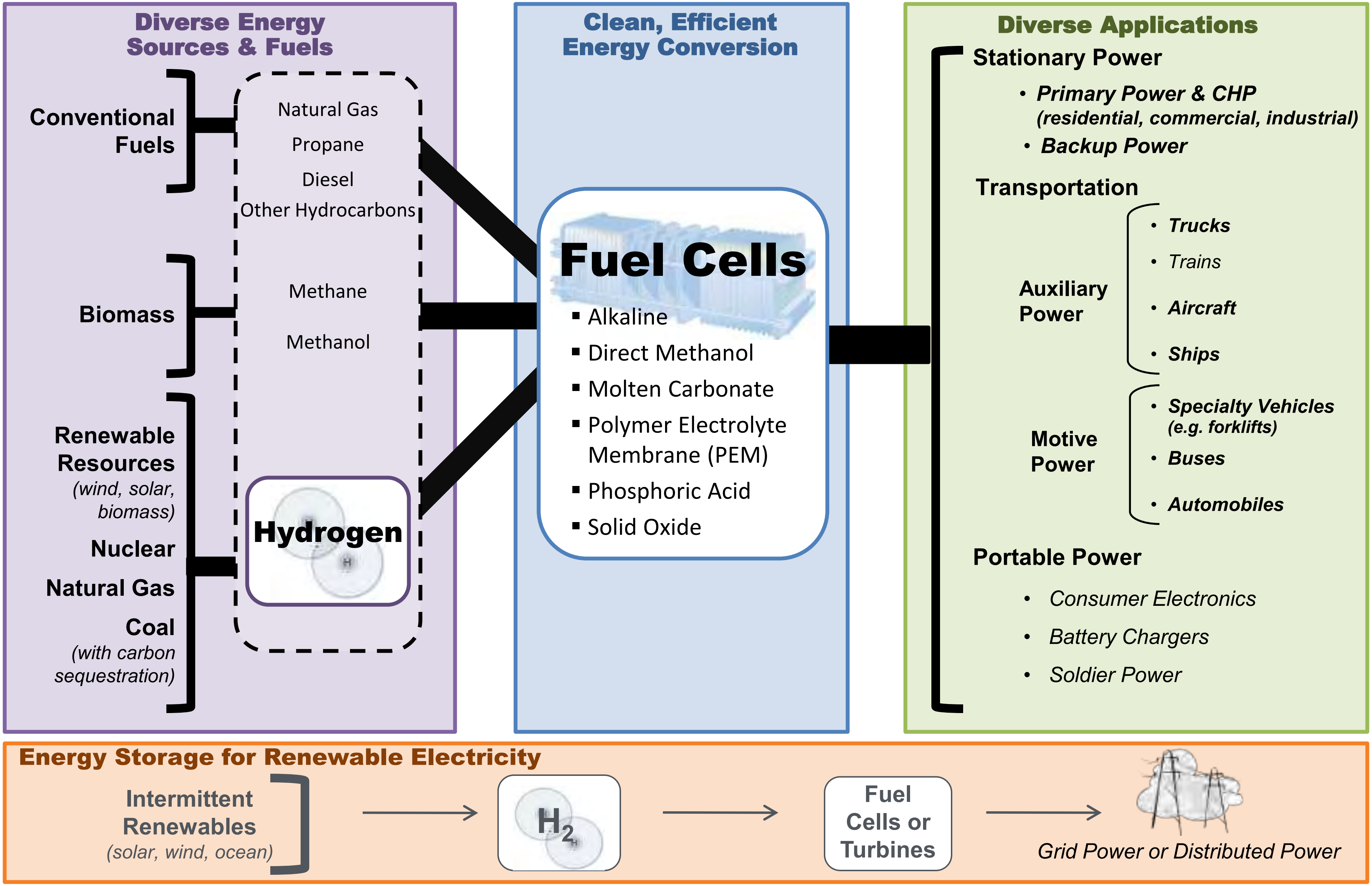
John Christensen P.E. (Speaking on behalf of Pete Devlin)
NREL Consultant to DOE

Agenda

- US DOE Fuel Cell Technologies Program
  - Progress against targets
- Market Transformation Activities
  - Material Handling Equipment Deployments
  - Critical Backup Power Deployments
  - Renewable Hydrogen for Transportation Applications
- DOD/DOE MOU Workshops
- Summary

Fuel Cells for Diverse Applications

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

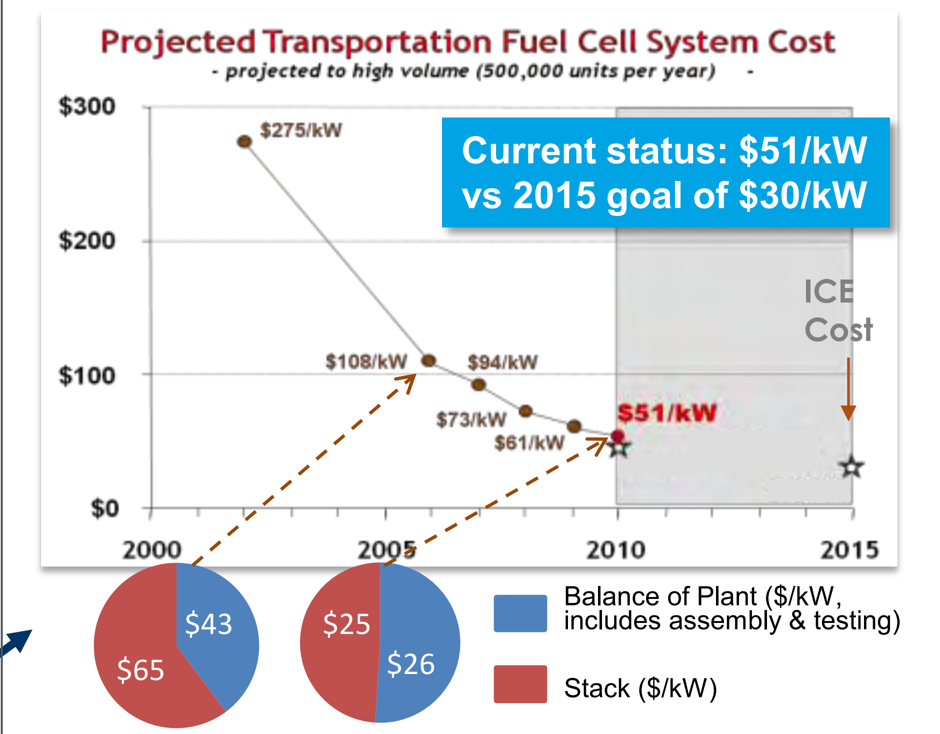


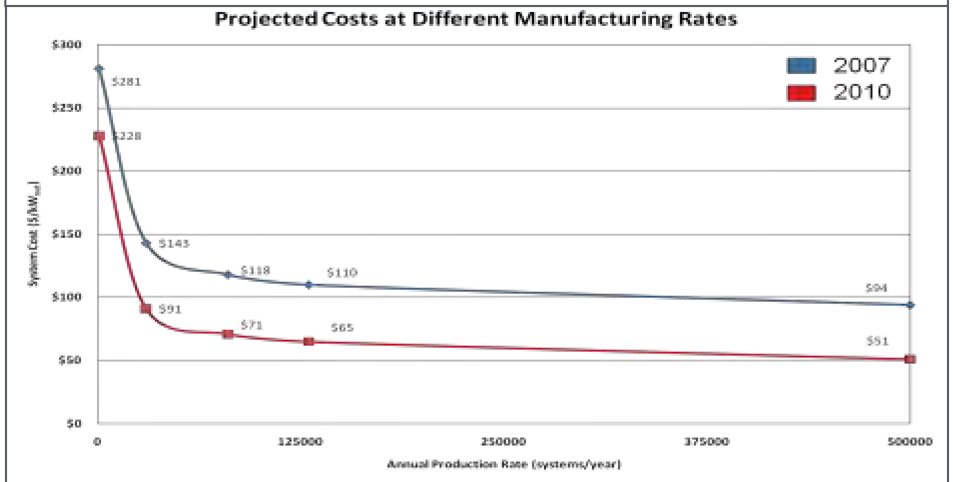
DOE Fuel Cell R&D — *Progress: Cost*

Projected high-volume cost of fuel cells has been reduced to $51/kW (2010)*

- ***More than 30% reduction since 2008***
- ***More than 80% reduction since 2002***
- ***2008 cost projection was validated by independent panel*****

As stack costs are reduced, balance-of-plant components are responsible for a larger % of costs.





**Based on projection to high-volume manufacturing (500,000 units/year).*

***Panel found $60 – $80/kW to be a "valid estimate": http://hydrogendoedev.nrel.gov/peer_reviews.html*

Deployments

Examples of Early Market Applications

Fuel Cells for Backup Power ...

- Provide longer continuous run-time, greater durability than batteries
- Require less maintenance than batteries or generators
- *May provide substantial cost-savings* over batteries and generators

A 1-kW fuel cell system has been providing power for this FAA radio tower near Chicago for more than three years.

(Photo courtesy of ReliOn)

Fuel Cells for Material Handling Equipment ...

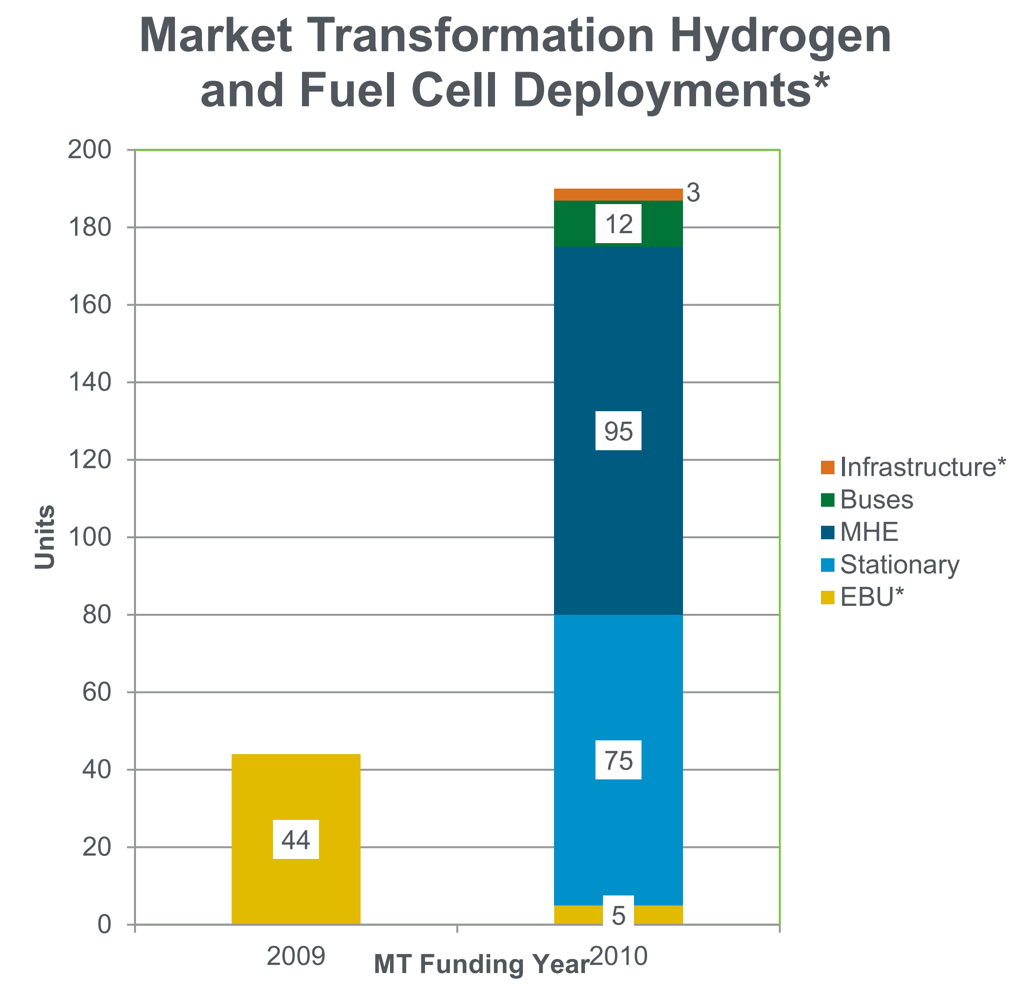
- Allow for rapid refueling — much faster than changing-out or recharging batteries
- Provide constant power without voltage drop
- Eliminate need for space for battery storage and chargers
- *May provide substantial cost-savings* over battery-powered forklifts

Photo courtesy of Hydrogenics

Fuel Cells for Data Centers ...

- Provide high-quality, reliable, grid-independent on-site critical load power
- Improve the effectiveness of data center power use by 40%, with combined heat-and-power (for cooling and heating)
- Produce no emissions
- Have low O&M requirements
- Can be remotely monitored

Market Transformation Deployments



*DOE ARRA Projects Not Included

Total Deployments by Type*

2009 Deployments ($5 Million)
- 44 EBU Units

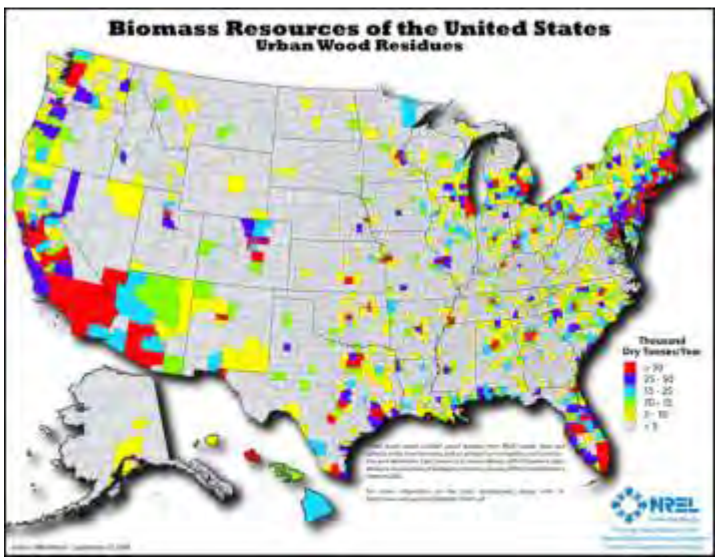
2010 Deployment ($15 Million)
- 5 Mobile Light Stands
- 75 Micro CHP Units
- 95 MHE Units
- 12 HICE Buses
- 1 Electrolyzer
- 1 Mobile Refueler
- 1 Hydrogen Reformer (Landfill Gas)

* Figures include Market Transformation funding only, ARRA and Other are excluded

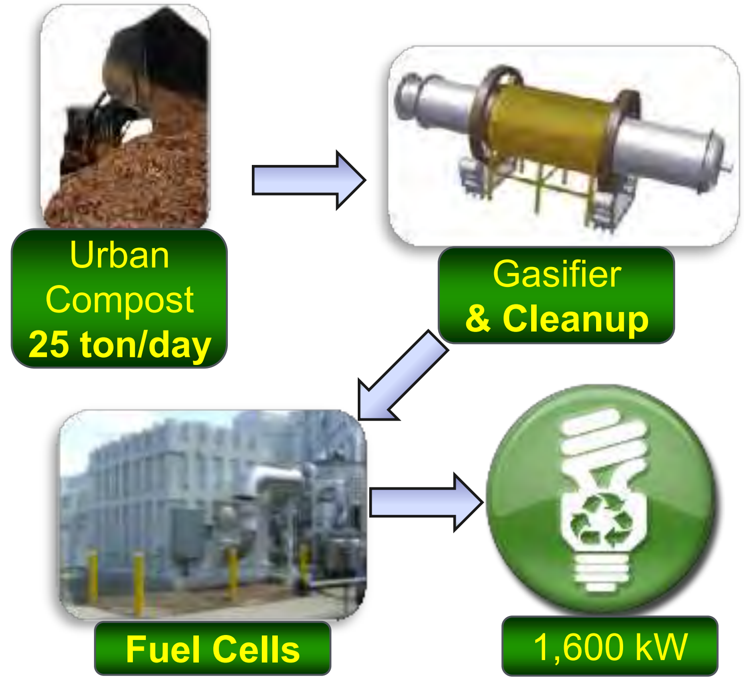
Waste To Energy Example

Los Alamitos Joint Forces Training Base (JFTB)

Los Alamitos JFTB



National Renewable Energy Laboratory
Innovation for Our Energy Future

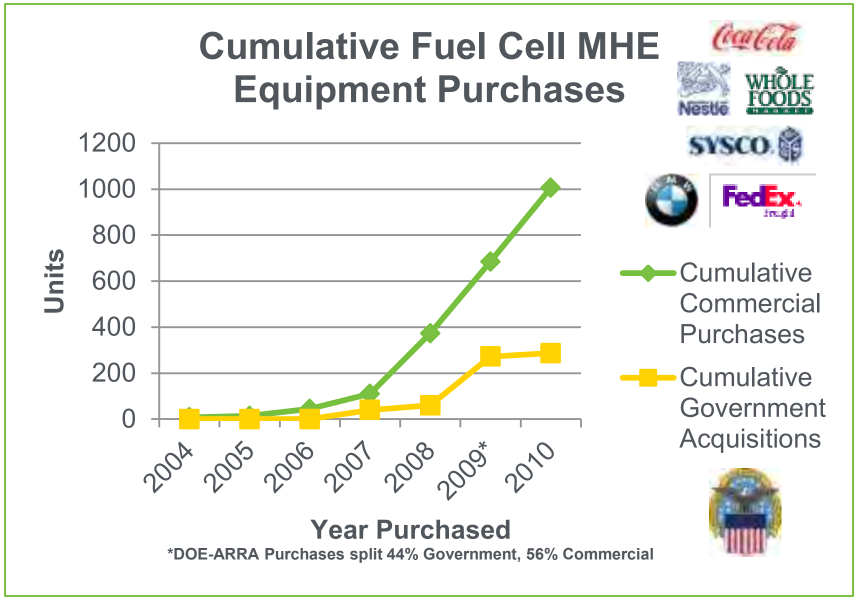


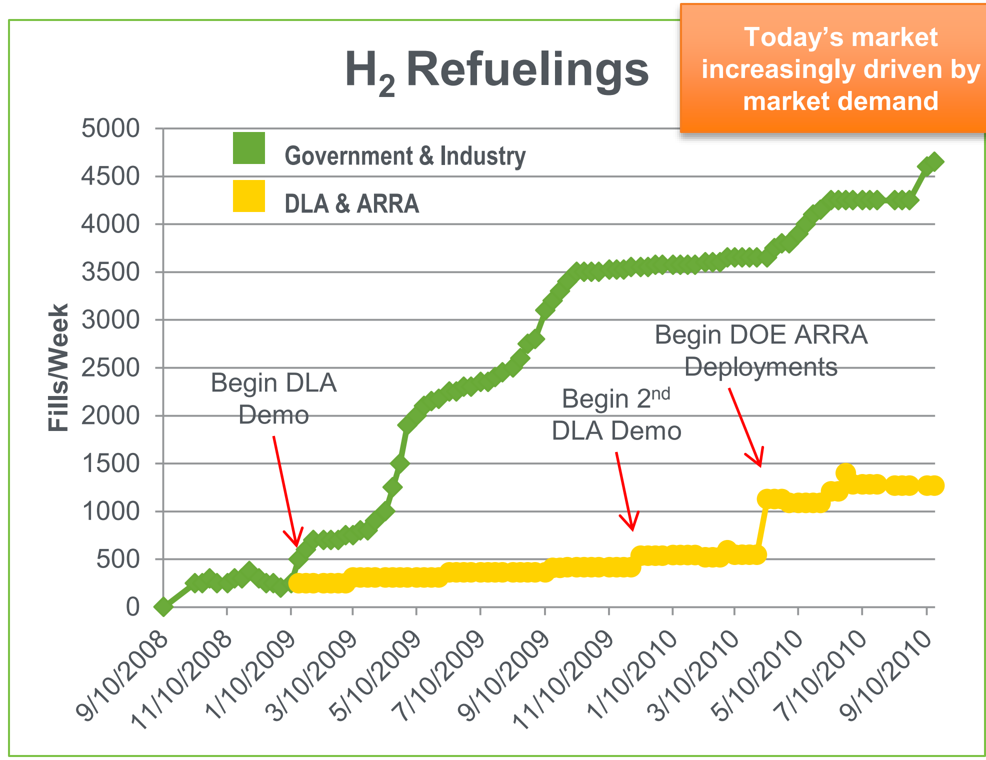
Resource potential for Los Alamitos

- 300 tons/day
- 19,200 kW

Urban wood waste is an abundant feedstock around the US

Government Assistance as a Catalyst for Industry Adoption





Fuel Cell MHE Market Example

- Early Procurement (2007-2009)
  - DLA began early fuel cell powered forklift procurements, 99 units
  - Multiple OEMs across sites in PA, GA, CA, and WA (Army)
- DOE-ARRA-funded Projects (2009)
  - Received over 50% cost share from industry
- Fully Integrated Fuel Cell Forklifts (2011)
  - Two forklift OEMs have announced plans to design a new class of forklifts around fuel cells

YR	Commercial Purchases	Cumulative Commercial Purchases	Government Acquisitions	Cumulative Government Acquisitions
2004	8	8	0	0
2005	6	14	0	0
2006	31	45	0	0
2007	65	110	40	40
2008	263	373	20	60
2009*	312	685	212	272
2010	321	1006	15	287

Material Handling Deployment Progress

Emerging Market Opportunity

- Value Proposition
  - Quick, easy indoor refills (3-10min)
    - 20-90 min/day for battery charging
  - Consistent power across entire shift
  - 10-20% Labor Productivity Savings

Deployments

✓55 at DLA DDSP, Susquehanna, PA

✓20 at DLA DDWG, Warner Robins, GA

The Defense Logistics Agency Susquehanna, PA depot has chosen to support full transition from their first adopter fuel cell project. This means purchasing MHE units under firm fixed price contracts.

- Next Steps
  - Program extension beyond demonstration which ends in Feb 2011
  - DDSP will release RFP to purchase 15 additional units

Emergency Backup Power

Advantages of Fuel Cells for Backup Power:

1. Provide longer continuous run-time, greater durability than batteries
   - Fuel Cells will last 15 years or more, depending on actual use
2. Require less maintenance than batteries or generators
3. Monitored remotely
4. Nearly 25% reduction in lifecycle costs for a 5-kW, 52-hour backup-power system*

Bundled DOD Multi Site Back-Up Power Project to Reduce Overall Cost of Deployment

Project Details

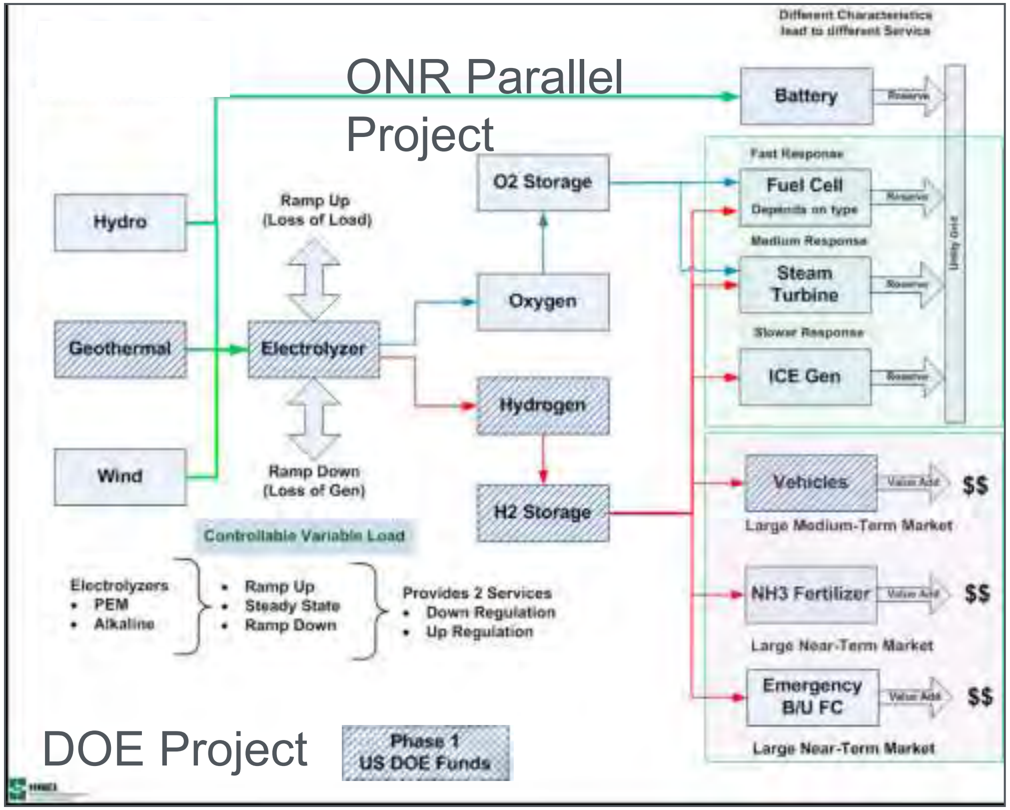
- ✓ 9 Host Sites
- ✓20 Separate Buildings
- ✓44 Units
- ✓~220kW

- U.S Army Aberdeen Proving Ground, MD
- U.S. Army Fort Bragg, NC
- U.S. Army Fort Hood TX
- U.S. Army National Guard Ohio
- U.S. Army Picatinny Arsenal , NJ
- NASA Ames Research Center, CA
- USMC AGGC 29 Palms, CA (2 Buildings)
- US Military Academy West Point, NY.
- Cheyenne Mountain Air Station

*SOURCE: *Identification and Characterization of Near-Term Direct Hydrogen Proton Exchange Membrane Fuel Cell Markets, Battelle Memorial Institute, 2007 (www.hydrogenandfuelcells.energy.gov/fc_publications.html)*

Grid Integrated Hydrogen Energy System

To help combat large amounts of variable generation from renewable sources a grid integrated hydrogen system is proposed to use hydrogen for energy storage.



Grid Integrated H_2 Energy System Benefits

- Provide hydrogen fuel to bus companies.
- Demonstrate electrolyzers as a grid management tool.
- Ability to respond quickly to increased and decreased loads.

Hydrogen ICE Buses

Deploy Hydrogen buses and inform the general public on the benefits of Hydrogen Fuel

- ✓ USMC Camp Pendleton
- ✓ Joint Base Pearl Harbor-Hickam
- ✓ Army CERL: Program Manager

Project Details

- ➢ 12 Ford HICE Buses
- ➢ 8 Different Sites
- ➢ H2 from Renewables
- ➢ DOD and Lab Sites, including one University Site
- ➢ Emphasis on Outreach
- ➢ 1000 + Impressions since 1st deployment in June

- Next Steps
  - More Outreach Events planned for all sites (12 Month Outreach Programs)

DOD-DOE MOU

Enhance Energy Security MOU

The purpose of this MOU is to identify a framework for cooperation and partnership between DOE and DOD to strengthen coordination of efforts to enhance national energy security, and demonstrate Government leadership in transitioning America to a low carbon economy.

Aviation APUs Workshop: 9/30/2010

- To begin discussing collaboration across DOD and DOE in keeping with the MOU
- To motivate RD&D for APU applications

Waste-to-Energy Workshop: 1/13/2011

- To identify DOD-DOE waste-to-energy and fuel cells opportunities
- To identify challenge and determine actions to address them

Shipboard APUs Workshop: 3/29/2011

- Hosted by ONR on March 29th, 2011
- Included USCG and Military Sealift Command

Aircraft Auxiliary Power Units

Goal

- **Develop a comprehensive hydrogen and fuel cell approach for aircraft**
- **Including onboard APU, GSE, ground transportation, and mobile lighting**

Boeing 787

Benefits of Fuel Cell APUs

✓ Increased efficiency
✓ Reduced emissions
✓ On-board water generation
✓ Combined-heat-and-power opportunities
✓ Reduced generator size & weight

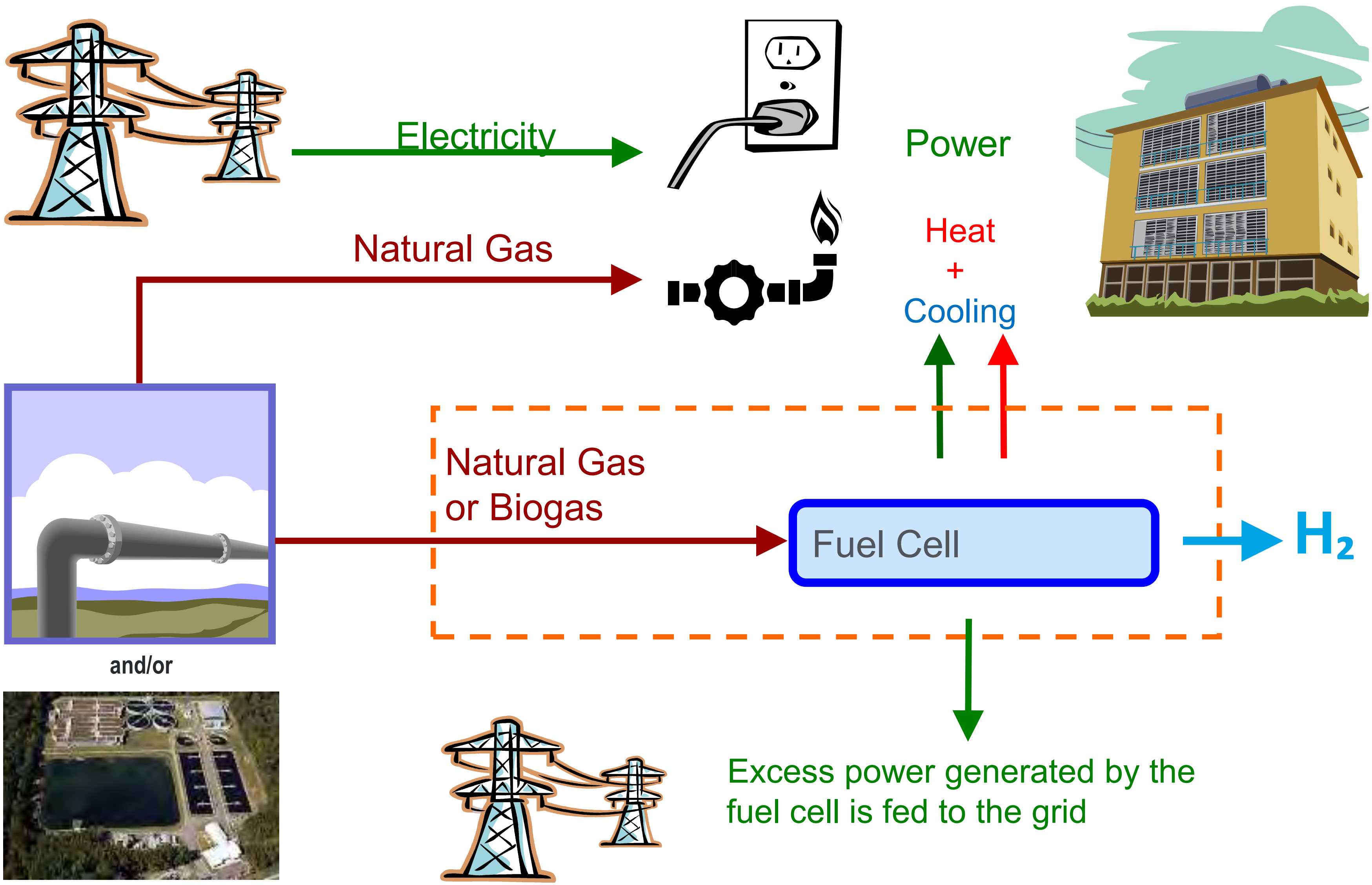
This year's focus

- Evaluate APUs size and configurations of fuel cell systems and scenarios.
- Evaluate technologies to provide peak power (PEM, high-temp. PEM, ultra-capacitors, turbines, batteries, etc.)
- Identify and quantify efficiency, cost, and emissions benefits of fuel cells in practice

To date

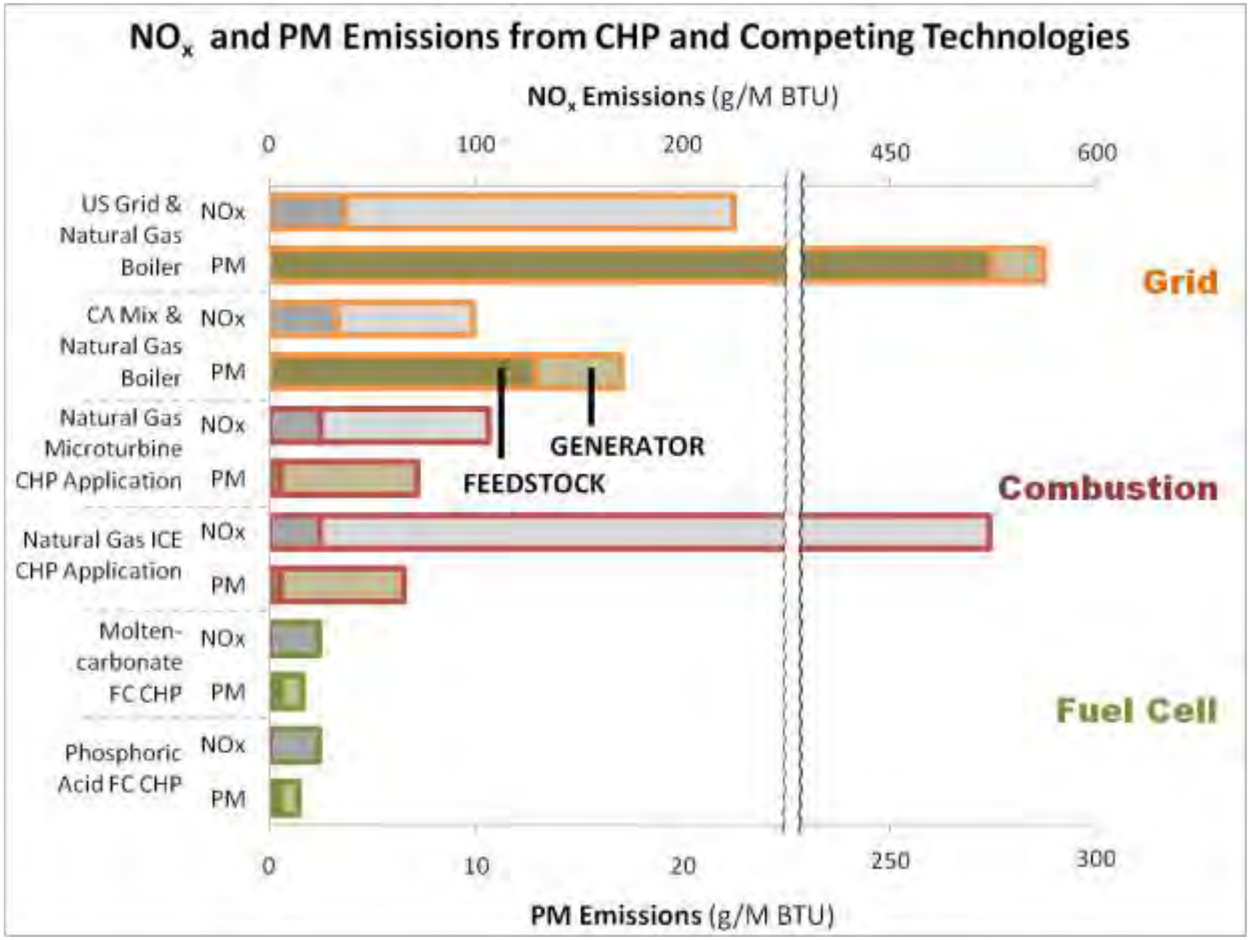
- Aircraft Working Group
- Aircraft APU Workshop
- PNNL/SNL analysis
- Launched SBIR topic
- Issued RFI topic

Overview of Combined Heat+Power



Stationary fuel cells offer significant reductions in criteria pollutant emissions.

Criteria Pollutant Emissions (g/M BTU)



Source: US DOE 1/2011

Criteria Pollutant Emissions from Generating Heat and Power. *Fuel cells emit about 75 – 90% less NOx and about 75 – 80% less particulate matter (PM) than other CHP technologies, on a life-cycle basis.*

Goal

- Compare LFG-produced hydrogen and delivered hydrogen in "real world" evaluation of MHE equipment.

Landfills generate landfill gas (LFG) from active microorganisms interacting with the waste. This gas can be converted into hydrogen and used to provide energy or fuel, effectively **turning trash into power**.

BMW Manufacturing site.
Courtesy of Waste Management World

Landfill Gas to Hydrogen Benefits

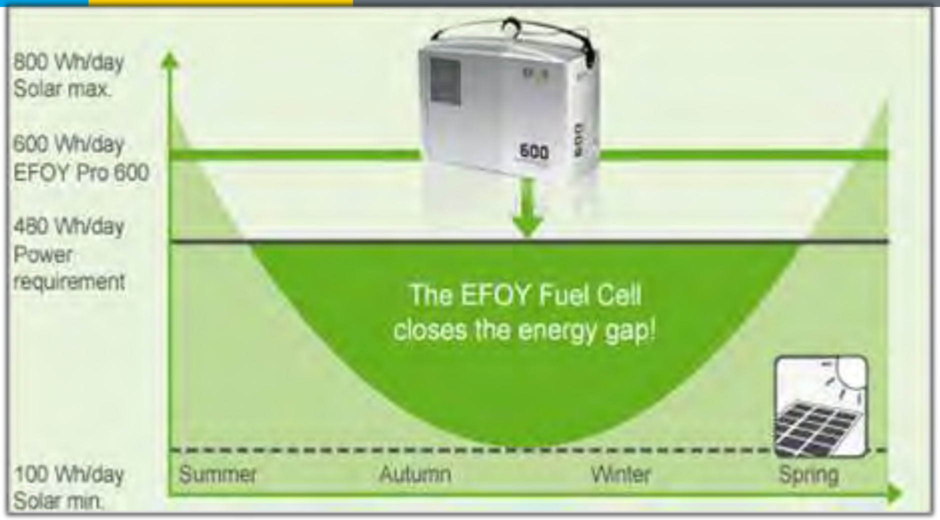
✓ Reduced emissions
✓ Additional power supply
✓ Additional vehicle fuel source

- **Potential Fuel Savings using Shipboard Fuel Cell to replace auxiliary gas turbines**
    - ONR demonstrated 48% efficiency @ 10W/l for molten carbonate ship service fuel cell operating on reformed JP5, and achieved 36W/l power density with improved reformer operating on low sulfur F76, JP5 and JP8.
- **Future Opportunities: Fuel savings for DDG 51 ship class with mechanical drive or hybrid electric drive:**
    - 15% fuel savings from 3-6MW fuel cell install
    - 12K bbls/ship/yr fuel savings
    - 20% fuel svngs. from 3-6MW fuel cell w/hybrid electric drive
        - 16K bbls/ship/yr fuel savings
    - 3.8 – 5.1% Total Maritime Fuel Savings (35 ship installs)
        - Total Maritime Fuel Consumption ~11M bbls/yr
- **Biofuel reforming would improve power density and performance, and help achieve SECNAV energy goals and sail Great Green Fleet in 2016.**

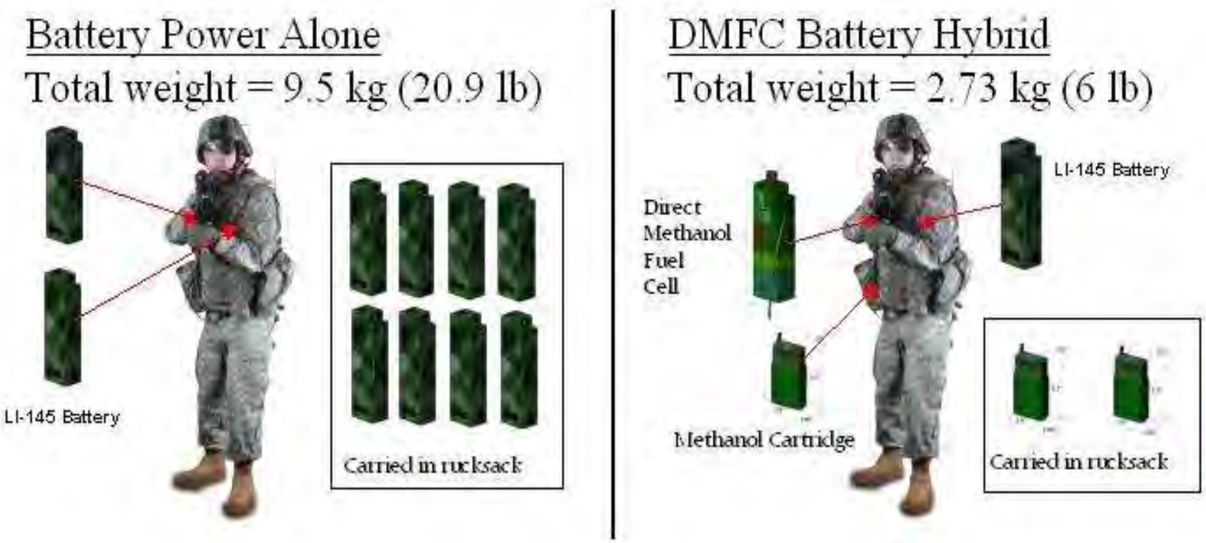
Bomse, Conner, Douglass, Partos, ~~-~~Shipboard Fuel Cell (SFC) Thrust, CME D0008923.A1/Final", Center for Naval Analysis, Sept 2003

Additional Examples – FC Applications

FC Battery Chargers
• Flexibility
• Long run times
• Grid independent
• Quiet
• Light weight
• Reduced down time
• Enables & complements intermittent renewables



FC Soldier Power
• Light weight
• Efficient
• Quiet
• Low heat
• Design flexibility



72 hour mission example

Source: USFCC

Thank you

For more information, please contact

Pete Devlin

peter.devlin@ee.doe.gov

hydrogenandfuelcells.energy.gov

Back Up

Combining modern PEM fuel cells and high efficiency plasma lighting, fuel cell mobile lighting provides superior performance.

Fuel Cell Mobile Light used at 2011 Golden Globe Awards (courtesy of SNL)

Benefits of Fuel Cell Mobile Lighting

✓40 hour duration (lighting)
✓ 3 kW of AC power available
✓ Illuminates 50 yds x 75 yds
✓ Suitable for indoor/outdoor use
✓ Very quiet! 43 dB noise level at 23 ft

Next Steps

- Real World deployments at SFO, State DOT (CA, CT), and the entertainment industry
- Publicize and further commercialize
- Continue to improve technology

Direct Methanol Fuel Cells

Fuel Cells for MHE using bio-methanol will have lower infrastructure costs.

Project Details

✓ 75 units

✓ 4 locations

✓ Engage Key Industry Stakeholders: Nissan

- **Next Steps**
  - Gather material handling equipment (MHE) performance data.
  - “Real world” evaluation and testing of equipment.

Stationary Fuel Cells: CHP

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Emerging Market Opportunity

- Combined Heat and Power and Combined Heat Hydrogen and Power
  - Efficiencies from 75% to over 85%
  - Multiple fuel sources (e.g. natural gas, biogas)

Photo credit: Verizon Communications.

During the cooling season, the high-grade waste heat from the fuel cells is used by two lithium bromide absorption chillers, contributing about 33% of the energy required for cooling.

Verizon Case Study

- Project Details and Results
  - 1.4MW CHP system
  - Natural gas supplied
  - 97% Availability since mid 2005
  - Near 100% reduction in CO_2, NO_x, and SO_x
  - Applied to critical prime power functions
    - Avg. total electrical loads of 2.5MW
    - 292,000 sq-ft facility

CHP Deployments

The Food Industry is an emerging market for stationary fuel cells

Announced Supermarket Deployments: Nine Sites Include

- **Whole Foods**
  - **3 sites**
- **Price Chopper**
  - **3 sites**
- **SUPERVALU(Albertsons/Shaws)**
  - **2 sites**
- **Ahold (Stop & Shop)**
  - **1 site**

- **Completed Food Producer Deployments:**
  - **Coca-Cola (800 kW) – another 800 kW under construction**
  - **Gills Onions (600 kW)**
  - **Pepperidge Farms (1.45 MW)**
  - **Sierra Nevada Brewery (1 MW)**

Green Communities

- –***Green Communities***” Goal – To leverage
  - residential, mixed-use, light commercial, municipal or state sites that have committed to mitigating their environmental impact.

  - identify communities that have adopted energy efficiency and conservation plans that are capable of leveraging their existing or planned investments with the deployment of hydrogen and fuel cells systems.

Potential Projects

Community requires system capable of integrating with existing renewable energy generators to produce hydrogen to fuel new fuel cell bus fleet	Fuel cell co-generation plant could provide sufficientt electric power and heat to meet community's requirements and help achieve energy efficiency and GHG emissions goals adopted by community.	Installation of electrolyzer would allow community to store and sell excess renewable energy production, generating a new revenue stream and fully utilizing renewable resources.

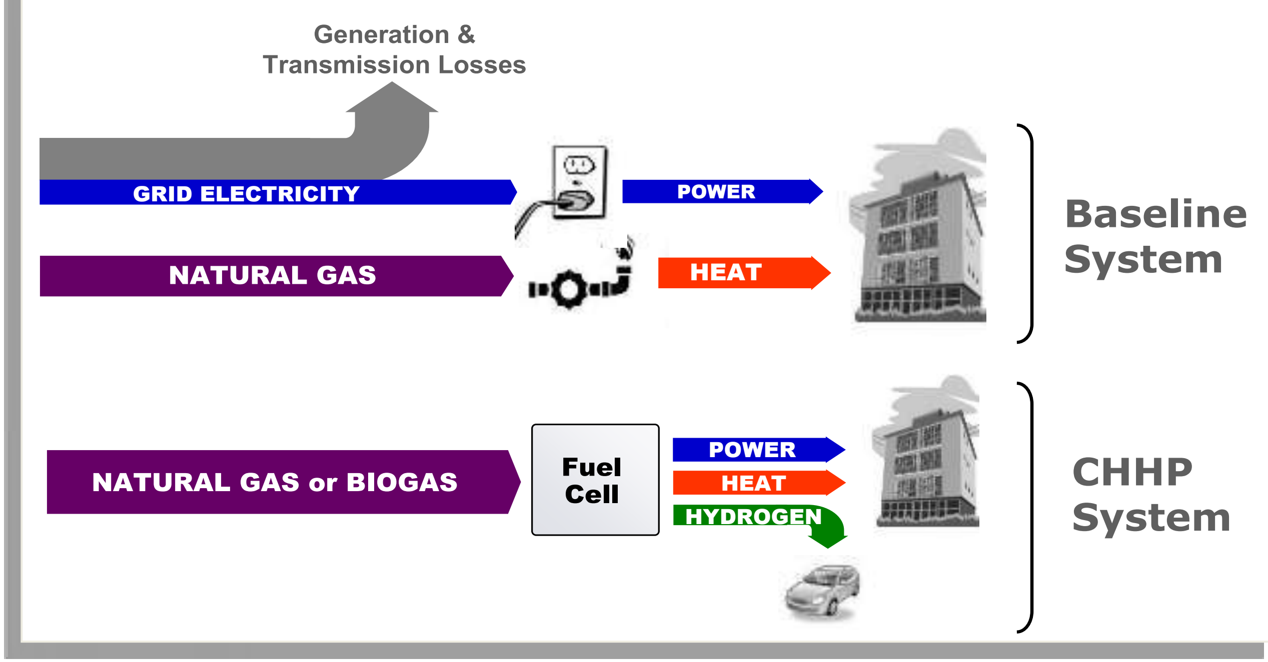
Technology Validation — Tri-Gen Highlight

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

We are participating in a project to demonstrate a combined heat, hydrogen, and power (CHHP) system using biogas.

- System has been designed, fabricated and shop-tested.
- Improvements in design have led to higher H_2-recovery (from 75% to >85%).
- On-site operation and data-collection planned for FY09 – FY10.

Tri-Generation (CHHP) Concept



Combined heat, hydrogen, and power systems can:

- *Produce clean power and fuel for multiple applications*
- *Provide a potential approach to establishing an initial fueling infrastructure*

Public-Sector Partners

South Coast Air Quality Management District

California Air Resources Board

2011 Joint Service Power Expo

High Energy Density Systems Planning: A collaborative process

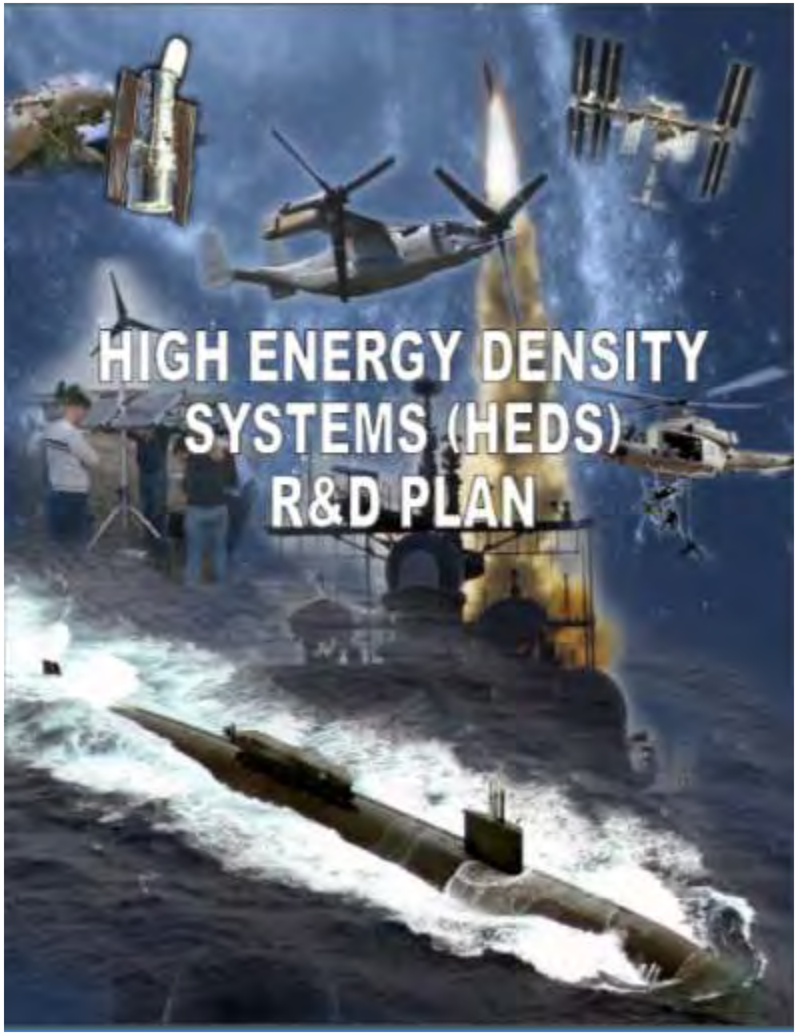
Kyle Werner, NSWC Crane
Division Manager, Energy, Power & Interconnect Technologies
3 May 2011

High Energy Density Systems (HEDS) Outline

- HEDS Document Overview
- HEDS Conclusions
- HEDS Paths Forward

HEDS Technology Planning Document: Overview

- Began with a NAVSEA request for action…
  - **Assist implementation of HEDS for Navy applications**
  - **Help coordinate efforts**
  - **Document technology development needs**
- Followed EO-IR "model"…
  - **Expert community invited**
  - **Held event July 2010**
  - **Resulted in plan document**



HEDS Technology Planning Document: Process Overview

Basic Research (6.1-6.2; TRL 1-3)	Applied R&D (6.3; TRL 4-5)	Eng. & Man. Dev. (6.4-6.5; TRL 6-7)	Production & Dep. (6.7-Proc; TRL 8)	Ops. & Support (O&M; TRL 9)

Build Knowledge Base	Introductions	Workgroup Orientation	Stakeholder Analysis	Systemic Challenges		**Tuesday**
Build Document	Build Technology List	Prioritize Technology List	Timelines	Technology Descriptions	Walkthrough	**Wednesday**
Analyze Document	Analysis	Critical Success Factors/Dependencies	Insights	Recommended Actions	"Blank Sheet" (Time Permitting)	**Thursday**
Workgroup Brief-out	Brief-out Prep	Brief-out Presentation				**Friday**

HEDS Technology Planning Document: Organization & Leadership

Sponsors:

George Drakeley, SES, SEA-05Z
Duane Embree, SES, Technical Director, NSWC Crane

Core Team:

Workshop Chair: Joe Gaines, NSWC Crane
Tech Leader: Sue Waggoner, NSWC Crane
Process Leader: David Smith, HBMG
David Cherry, NAVSEA 05Z34
Kevin Cook, NAVSEA 05Z34
John Dement, NSCW Crane
Eric Dow, NUWC Code 823
John Dow, NOSSA Indian Head
June Drake, NSWC CTO
Joe Fontaine, NUWC Newport
Peter Keller, NSWC Carderock
Bill Kleinebecker, HBMG
Corey Love, NRL
Scott Littlefield, NSWC Carderock
Brett Stafford, NUWC Keyport
Al Stern, NSWC Indian Head
Sam Stuart, NSWC Crane
Kyle Werner, NSWC Crane

Contractors:
HBMG – R&D Plan Process Consultants
TSC – Workshop Support
McKean Defense Systems – Logistics Support

Workgroup Co-chairs

Fuel Cells
John Heinzel, NSWC Carderock at Philadelphia
Ian Peek, NSWC Carderock at Philadelphia
Ken Burt, NSWC Crane

Lithium Rechargeable Batteries
Sam Stuart, NSWC Crane
Lloyd Zilch, NSWC Crane

Other Electro-chemical Batteries
Bill Johnson, NAVAIR
Justin Govar, MARCORSYSCOM

Advanced Energy Conversion Systems
Jerry Czarnecki, NSWC Crane
Tom Adams, Purdue

Capacitive Storage
Tricia Smith, NSWC Carderock

Safety/Risk
Dave Cherry, NAVSEA 05Z34
Mark Tisher, NSWC Crane
Larry Ruckriegel, NSWC Crane

Energy Systems Management
Frank Ferrese, NSWCCD Philadelphia
Mike Golda, NSWCCD Philadelphia

Advanced Application Technology
Scott Duncan, NAVSEA

HEDS Technology Planning Document: Mission/Vision

- Provide a Research & Development Plan with key technological elements that can be used for planning *safe* and *highly effective* HEDS for US Navy (USN) systems.
- Address HEDS used in USN systems above personnel carried systems and below primary propulsion and main electrical power for ships.
- Provide a comprehensive document that communicates the timing of technological development in this domain over the 2010-2030 strategic period.
- Provide key HEDS technological information for making strategic decisions in selecting technologies using mutual terminology, established technology maturity definitions, and a shared understanding of key issues.

HEDS Technology Planning Document: Synergistic Relationships

HEDS planning and development leveraged a variety of other Federal Agency Power & Energy future looking documents, some of which include:

Document	Sponsor	Scope	Distribution
DoD Power Sources Technology Roadmap	DoD JDMTP	Provides a concise, coherent strategy that assures the state of the art power sources are available now and in the future to the Nation's Warfighters	US Gov Agencies and their contractors
S&T UUV Energy Roadmap	ONR	Provides UUV energy sources for future Warfighter requirements	US Government only
Torpedo Energy & Propulsion Roadmap	ONR	Provides Torpedo energy and propulsion sources for future Warfighter requirements	US Government only
HEDS R&D Plan	NAVSEA	Provides a future focused strategic technology R&D plan with key technological elements that can be used as a tool for planning highly effective, safe, affordable High Energy Density Systems for Navy systems	US Gov Agencies and their contractors

HEDS Technology Planning Document: Focus Areas

- The plan document covered seven focus areas:
  - Fuel Cells
  - Lithium Rechargeable Batteries
  - Other Electrochemical Batteries
  - Advanced Energy Conversion Systems
  - Capacitive Storage
  - Safety/Risk
  - Energy Systems Management
- Developing technology plans followed an adopted approach:
  - Identify needs
  - List technology solutions
  - Propose development bridges for the gaps

Intention was to produce a tool for collaborative HEDS development…

HEDS Technology Planning Document: Workshop Attendees

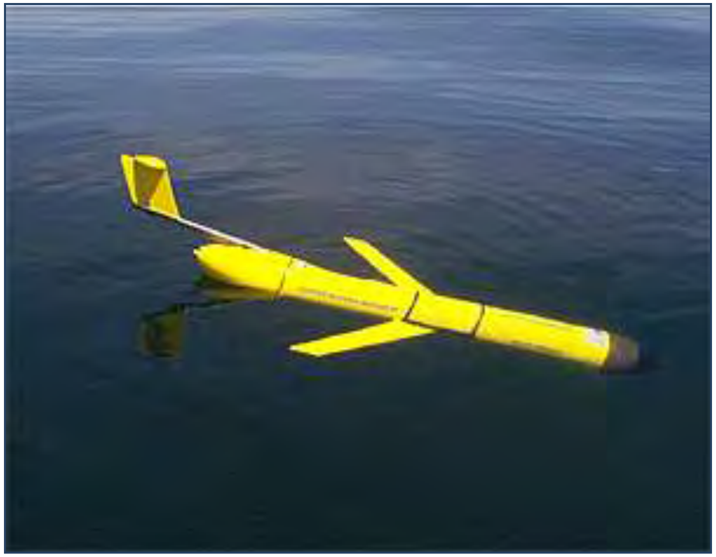
2011 Joint Service Power Expo

HEDS Technology Planning Document: Technology Boundaries

Factor/Year Fielded	2010	2016	2030
Max Gravimetric Density	200 Wh/kg	1000 Wh/kg	2000 Wh/kg

The boundaries represent the consensus achievable levels.

The plan will address HEDS used in US Navy Storage and Conversion systems above personnel carried systems and below primary propulsion and main electrical power for ships.



HEDS Technology Planning Document: Highlight Conclusions

Conclusion #1. Significant safety and risk issues are present; particular focus on materials.

Conclusion #3. Future HED systems will require hybrid solutions.

Conclusion #4. Providing high energy density and power needs a system of systems approach.

Conclusion #6. Must have domestic sources for some materials & possibly manufacturing equipment.

Conclusion #8. Need new/improved collaboration, resource sharing, and knowledge transfer.

Conclusion #10. Must increase funding of High Energy Density Systems to address the hard problems.

HEDS Technology Planning Document:
Sample Focus Area, Lithium Rechargeable Batteries

Insights

- Goal of 2000 Wh/kg in 2030 is unattainable in this area
- 2x improvement is possible for Li Ion (up to 500 Wh/kg)
- First generation of battery management has been lifted from non Li world. Li is tricky, next-generation must be Li specific
- Federal focus on alternative energy is diminishing supply of S&T skills
- Navy will benefit from collaboration in this area
- We will need to combine funding to achieve promise of Li ion
- We are behind other countries
- We need a better technology transition process

Lithium Rechargeable Batteries

Basic Research (6.1-6.2; TRL 1-3) | Applied R&D (6.3; TRL 4-5) | Eng. & Ma (6.4-6.5; T

HEDS Technology Capabilities														
Tier 1	Tier 2	Tier 3	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Li Ion High Energy													
	146 Wh/kg Baseline		P										
	1.6X		A		E				P				
	2X		B					A			E		
Li Ion High Power													
	75 Wh/kg baseline		P										
	1.35X		A		E				P				
Li Sulfur			B							A			
Li Fluorine			B										
Li MH (Ni) (and other possible hybrids)			B										
Li Air			B										
Li FeS_2			B						A				
Systems inter / construction			A					E					
Allied Technologies													
Carbons													
Anodes													
Cathodes													
Binders													
Conductive agents													
Monitoring inside cell													
	Internal Ref												
Electrolyte (making better batteries)													
	High temp		B			A				E			P
	Low Temp			B		A				E			P
	Overcharge		B						A				E
	Flammability		B			A				E			P
	Cycling		B			A				E			P
	Solid Electrolyte												
Binderless													
Manufacturing science (Critical Need)													
	Coating/drying		A										
	Cutting		A										
	Welding		A										
	Packaging (sealing)		A										
	Realtime, online sensors		A				E			P			
Super Iron example of far off tech (advanced tech)													
Separation													
	Membrane tech												
	Ceramic												
	H2O												
	O2												
	fuel cells												
Charging													
	innovative taking advantages of the deltas		A					E			P		
Next Gen BMS													
	sensor tech (inbedded tech)												
		External to cells	A			E			P				
		Internal to cells	A				E			P			
	Engineering Battery Models												
		Ph 1 early efforts	A			E			P				
		Ph 2 long term	B			A				E			
	Systems Integration		A				E			P			
	Health Monitoring		A				E			P			
Material Science													
A system of systems (hybrid, cap, battery, fuel cell system)													

HEDS Technology Planning Document: Way Ahead…

Actions Already Taken:

- Warfare Centers have aligned S&T investments
- Industry partners have incorporated elements of the HEDS R&D Plan into their IR&D Plans
- SEA 05Z has established a High Energy Chemical Safety Storage Office (HECSSO)
  - A Platform Integration High Energy Safety Manager has been appointed
  - Navy High Energy Storage System Safety Manuel published

Way Ahead:

- Document is finalized and being routed for signature
- Briefings to Warfare Centers and NAVSEA headquarters
- Charter a HEDS Working Group in preparation for HEDS Update in 2012

HEDS Technology Document POC: Ms. Sue Waggoner, NSWC Crane, 812.854.4103, susan.waggoner@navy.mil

HEDS Technology Document:
Back – Up Slides….

HEDS Document Background: Overall Conclusions for lithium rechargeable cells - cont

Technology Gaps

- For meeting 2x energy density improvement: cathodes, other materials for anode & electrolytes
- Battery Management Systems at all levels, modeling and packaging to improve safety over next 5 years
- Next gen of membrane technology
- Material availability at a reasonable price, especially for carbon nanotubes, $FePO_4$, and Nickel Manganese Cobalt materials

Brick Walls

- To exceed 2x energy density improvement (up to 1000 Wh/kg):
  - Separation technology (i.e., ionic membranes
  - Dendrites
  - Cathode technology (catalyst)
  - Electrolyte for higher voltage systems
  - Alternatives to flammable organic electrolytes
- No accelerated models/methods for life testing

Recommended Actions

- Improve materials and electro-chemical systems):
  - Nonflammable electrolytes
  - Higher energy density materials (alloys/metals)
- Develop new materials
  - Cathodes using nano-materials
  - Membrane technology (ionic exchange)
- Enhance efforts in improved Safety
  - With better battery management systems and sensors
  - Modeling and simulation
- Perform further analysis on Li-S and Li Air viability
  - Following the timeline foundation
  - Continue R&D plan improvements
- Improve communication
  - Develop a Li ion specification
  - Higher levels of collaboration
  - Partner with others to achieve greater goals

Progress against goals for 2010…

Recommended Actions

- Improve materials and electro-chemical systems):
  - Nonflammable electrolytes → NASA most, ARL several, NRL one effort
  - Higher energy density materials (alloys/metals) → DOE most, ARL/NASA many, Navy some
- Develop new materials
  - Cathodes using nano-materials → DOE most, ARL several, Navy some effort
  - Membrane technology (ionic exchange) → Little effort
- Enhance efforts in improved Safety
  - With better battery management systems and sensors → DOE most, ARL, AFRL some effort
  - Modeling and simulation → NASA most, DOE, ARL, Navy some effort
- Perform further analysis on Li-S and Li Air viability
  - Following the timeline foundation
  - Continue R&D plan improvements → DOE some, ARL some effort
- Improve communication
  - Develop a Li ion specification → JDMTP TWG, AF-AIAA, Navy efforts
  - Higher levels of collaboration
  - Partner with others to achieve greater goals → Initial discussions

Overall, commercial/university have most efforts

NAVSEA WARFARE CENTERS CRANE

STRATEGIC MISSIONS

Joint Services Power Expo
ARPA-E BEEST & NSWC Crane

Advancing Power Systems Technology

David G. Miller

Manager, Test and Evaluation Branch,

Energy, Power & Interconnect Div., NSWC Crane

May 2-5, 2011

ARPA-E History

- America Competes Act establishes Advanced Research Projects Agency-Energy (ARPA-E) in 2007
- Funded $400M in 2009 by American Recovery and Reinvestment Act
- ARPA-E mission is to fund projects that will enhance the economic and energy security of the U.S., and ensure that the U.S. sustains a technological lead in developing and deploying advanced energy technologies

ARPA-E Principles

- Funding High Risk/High Reward R/D projects that may not otherwise be pursued due to high risk of failure
- Cross disciplinary approach using government labs, private industry and academia
- Selected performers will be funded with deliverables/milestones being actual power systems that can be measured for success against program metrics

ARPA-E Programs

- Innovative Materials & Processes for Advanced Carbon Capture Technologies (IMPACCT) Electrofuels
- Grid-Scale Rampable Intermittent Dispatchable Storage (GRIDS) Microgrid Technology
- Agile Delivery of Electrical Power Technology (ADEPT) Power Transmission / Control
- Building Energy Efficiency Through Innovative Thermodevices (BEET-IT)
- Batteries for Electrical Energy Storage in Transportation (BEEST) Advanced Power Systems

BEEST & NSWC Crane

- In line with the DoE / DoD overarching MoU of July 2010
- BEEST purpose is to develop and test new, next generation power systems and provide benefits to US Industry.
- The Energy Power & Interconnect Technologies Division, Test & Evaluation Branch at Crane Division Naval Surface Warfare Center will work with ARPA-E and their performers to develop program specifics and independently verify/validate BEEST test assets compared to actual test metrics.

ARPA-E BEEST Metrics for Success

- Specific Energy Density – 400Wh/Kg
  - Cell Value @C/3
- Volumetric Energy Density – 600Wh/L
  - Cell Value @C/3
- Volumetric Power Density – 1200W/L
  - Cell 80% DOD, 30 Sec
- Specific Power Density – 800W/Kg
  - Cell 80% DOD, 30 Sec
- Cycle Life
  - 1000 @ 80% DOD
- Temperature Tolerance
  - -30C to 65C
- Self Discharge
  - < 15% / Month
- Safety
  - Over Charge, Heat, Crush

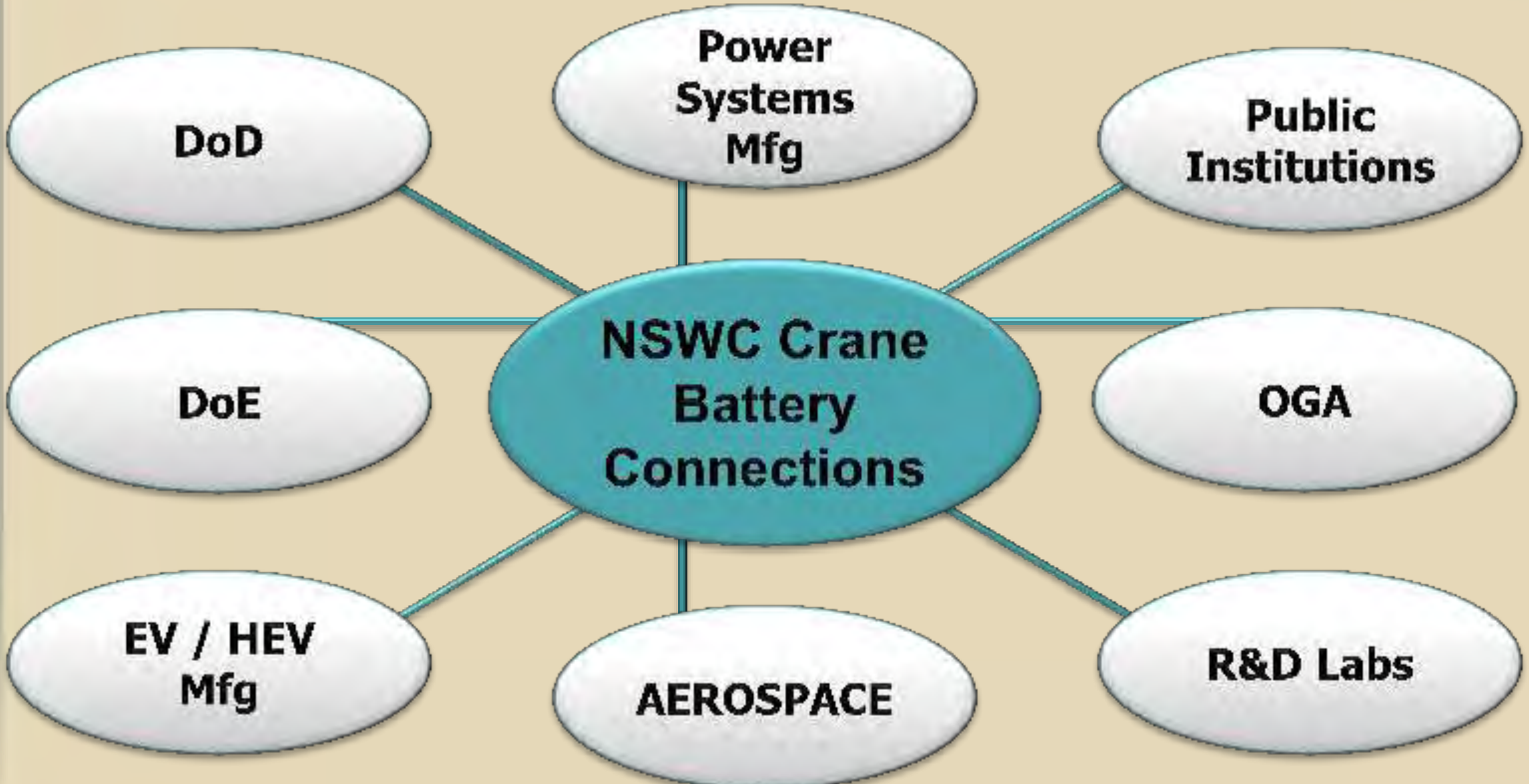
BEEST Performers

- MIT
- Fastcap
- Pellion
- Recapping Inc
- Inorganic Materials
- Planar Energy
- Missouri Institute of Tech
- Sion
- Arizona State University
- Envia
- Applied Materials
- Stanford University / Honda Support
- Polyplus
- ReVolt
- Eagle Picher
- BNL
- Max Power
- Nanolab
- A123
- Rutgers University
- NREL
- U of Florida/Florida Central
- U of Colorado Boulder
- UC SanDiego
- U of South Florida
- Penn State

BEEST Performer Ideas & Concepts

- All Electron Power System
- Solid State Power System
- Using Additional Valence Electrons
- Semi Solid and Fluidic Batteries
- Protonic Electrochemical Capacitors
- Lithium Air
- Sodium Power Systems
- Advanced Lithium Ion/Polymer
- And Others

Networking for Greatest Benefit



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Energy, Power & Interconnect Technologies Division Formal Charters

- NAVSEA Center of Excellence on Batteries
- Technical Direction Agent (TDA) for Standard Missile Batteries
- Cognizant Field Activity (CFA) for Aircraft Batteries
- TDA for Navy Special Warfare Batteries
- ISEA for Submarine Batteries
- MoU for Army Missile Command Batteries
- Interagency Agreement With FAA
- ISEA for SDV Batteries
- TDA for ASDS Batteries
- Interagency Agreement With DoE

Energy, Power & Interconnect Technologies Division Capabilities

- Over 2000 Work Years experience
- ~ 153 Personnel
- ~ 60% are Engineers and Scientists; 6 PhD’s
- Unbiased Independent Test Lab
- Established Government / Industry Team
- NOSSA Technical Agent for lithium battery safety.

Electrochemistry Experience
Battery Types

<table>
<tr><th>Alkaline (Sealed/Vented)</th><th>Lithium (Reserve/Active)</th><th>Thermal</th></tr>
<tr><td rowspan="3">Aluminum-Oxygen (Air)
Cadmium-Oxygen (Air)
Carbon-Zinc
Mercury-Cadmium
Mercury-Zinc
Nickel-Zinc
Nickel-Iron
Nickel-Cadmium
Nickel-Hydrogen
Nickel-Metal Hydride
Silver-Zinc
Silver-Cadmium
Silver-Hydrogen
Silver-Metal Hydride
Silver-Iron
Zinc-Manganese Dioxide
Zinc-Oxygen (Air)</td><td>Carbon Monofluoride
Copper (II) Oxide
Copper Sulfide
Iodine
Ion
Iron Disulfide
Oxyhalide
Polymer
Sulfur Dioxide
Sulfuryl Chloride
Thionyl Chloride
Vanadium Pentoxide</td><td>Calcium/Calcium Chromate
Calcium/Potassium Di chromate
Lithium Iron/Iron Disulfide
Lithium Aluminum/Iron Disulfide
Lithium Silicon/Iron Disulfide
Lithium Silicon/Cobalt Disulfide
Magnesium/Vanadium Pentoxide</td></tr>
<tr><th>Other</th><th>Lead-Acid</th></tr>
<tr><td>Seawater
Ammonium
Sodium-Sulfur</td><td>Absorbed Electrolyte
Antimony Grid
Calcium Grid
Gel Electrolyte
Flooded Electrolyte
Pure Lead Grid</td></tr>
</table>

Capacity Ranges: 0.03 to Tens of Thousands of Ah

Energy Power & Interconnect Technologies Division

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Equipment & Facilities Capabilities

- 21 Custom Test Control Systems
- 27 COTS Test Systems (Arbin, Bitrode Maccor PEC, TSC, EDA)
- Electronic Loads and Power Supplies

  up to 80 KW (240Vdc/300A; 120Vdc/600A)
- Full Environmental Test Capabilities
- Unlimited Abuse and Safety Test Capabilities
- Dissection and Materials Analysis Capabilities
- Unique High Energy Battery Test Facility
- Remote Ordnance Test Range
- Remote Underwater Test Range

Equipment & Facilities Capabilities

Nail Penetration

Shock & Vibration

Temp, Altitude & Humidity

Gas & Pressure

Acceleration

Conclusion

- The NSWC Crane Division, Energy Power & Interconnect Technologies Division is proud and eager to be part of this new and exciting DoE ARPA-E technology advancement initiative

- ARPA-E Director:
  – With the energy concerns of today, the Country cannot afford for this initiative to fail…..
  – The success of ARPA-E BEEST will change the way we all live.

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Advancing Renewable Energy Technology Commercialization

through

Federal, State and Local Collaborations

Russ Keller
Vice President, ATI
3 May 2011

Who We Are

SCRA …

- Is a non-stock, tax-exempt **applied research and commercialization services company** with more than 25 years of experience building multi-organizational teams.

- Currently **manages more than 100 national and international programs worth over $1B** in applied R&D contract value.

SCRA

What We Do

SCRA…

- **Leads applied research and commercialization** across a diverse range of industries
- Facilitates **technology solutions** with broad-industry involvement and impact
- Provides **commercialization services** for rapid, industry-wide technology implementation
- **Creates custom collaborations** with leaders from industry, government, and academia
- Executes **objective leadership** in an environment of trust where competitors collaborate for mutual benefit

What We *ALSO* Do

SCRA…

- **Manage three research parks** in the state of South Carolina (Charleston, Columbia, Clemson)

- **Execute economic development mandates from the South Carolina General Assembly**
  - **Construct, staff and manage three Innovation Centers** within the state
  - Work with the state's three research universities to **accelerate commercialization of university-generated Intellectual Property**
  - **Provide support services for "knowledge economy" business formation and growth…including seed venture capital investments**

A Unique Combination….

- **State Economic Development Mission** *and*
- **Technology Solutions and Services Focus** *supported by*
- **Infrastructure for Innovation**

….where the whole is greater than the sum of the parts.

Overview

- **The Power and Energy Challenge**
  - Mission requirements; capability needs
  - Executive Order 13514 direction
  - DoD and Service-specific vision / guidance
  - Budgetary constraints
- **Potential Solution Set**
  - Buy "off the shelf"
  - Develop internally (ONR, ARL, AFRL, UARCs, etc.)
  - Develop externally
    - "One off" contract to meet specific need
    - Long term contract to meet this and future related needs
- **Proposed Solution – Go to market…..without having to go it alone**
  - Successful case studies
  - Emerging opportunities

A Challenging Landscape

- **E.O. 13514 (October 2009)**
  - Reduce energy intensity in buildings
  - Increase use of renewable energy; implement renewable energy generation projects
  - Reduce use of fossil fuels
  - Reduce GHG emissions
- **DoD / Service-specific vision/guidance (Navy as example)**
  - October 2010 “Navy Energy Vision”
    - By 2020, half of total Navy energy consumption afloat from renewables
    - Sail the “Great Green Fleet” by 2016 (nuclear, hybrid-electric ships running on biofuel, aircraft flying on biofuel)
    - By 2020, half of Navy’s total energy consumption ashore from alternative sources
    - By 2020, half of Navy installations “net-zero” energy consumers
- **Budgetary constraints**
  - Deficit reduction pressure
  - Competing Service budget priorities (recapitalization, maintenance and repair, etc.)
  - DoD acquisition efficiency improvement initiatives

Potential Solution Set

- **Buy commercially-available (COTS)**
  - Must accommodate military-unique requirements / operating environment
- **Develop internally (DoD labs or University Affiliated Research Centers)**
  - Many, but not all skill sets are available "in house"
  - Cost effectiveness jeopardized if unique new infrastructure required
  - **There is no dedicated UARC for power and energy technologies**
- **Develop externally ("traditional" contract with outside providers)**
  - May or may not need to fund new infrastructure
  - Government's overhead challenge grows with multiple, "one-off" contract transactions
  - Breadth of capability challenge grows with long term contract to single provider having deep but narrowly-focused skill sets
- **Develop jointly with others**
  - Other services
  - Other federal agencies
  - Non-federal entities (including consortia of private industry / academia entities)

Potential Solution Set

Increasingly, the answer seems to be….

OPP / OPM

(Other People's People; Other People's Money)

Given the significant overlap of power and energy requirements, objectives and research assets across Services, federal agencies and the private sector, the opportunities for mutually-beneficial collaborations are significant

- Affords advantages of shared infrastructure, shared awareness, multiple opportunities for technology transition
- This approach is consistent with current DoD efficiency initiatives

However,

- No "silver bullet" template for every case, but worth evaluating the extra effort required for multi-party collaboration versus the potential payoff if successful
- Even if the will to collaborate is there and the potential payoff is evident, some degree of herding cats is going to be required

Initial Considerations

- Does the “pain” exist in more than one Service or agency?
  - **Is there interest by more than one “customer?”**
- Does the solution require university or other research assets (people and/or facilities)?
  - **Who needs to be part of developing the solution?**
- Does the “pain” extend to the private sector?
  - **Is there a shared interest in the private sector for finding a solution?**
- Does geography matter?
  - **Are there federal, state or local incentives that can reduce the cost of developing the solution?**

Federal Landscape

- **Potential "Customers" for Power and Energy Solutions**
  - DoE
  - DoD
  - DHS
  - USDA
  - DoT (FTA)
  - EPA
  - DoC (Economic Development Agency)

- **Financial Incentives for Renewable Energy**
  - Investment Tax Credits
  - Internal Revenue Code / Treasury Regulations for non-profit organizations

State Landscape

- **Varies by State**
- **South Carolina has several legislative initiatives very supportive of renewable energy technology in general, and hydrogen and fuel cell technology in particular**
  - Research Centers of Economic Excellence Act (2002)
  - Research Innovation Centers Act (2005)
  - Industry Partnership Act (2006)
  - Hydrogen Infrastructure Development Act (2007)
- **Fuel Cells 2000 "State of the States" report (Spring 2010) listed South Carolina as one of the top 5 states in the US in advancing hydrogen and fuel cell development**
  - Others were CA, OH, CT and NY
  - SC cited specifically for "promoting demonstrations, hydrogen stations and business development"

Collaboration Case Studies

- “Traditional” model is a Federal Agency - Industry (or Academia) partnership
  - Agency solicits solutions to meet requirements
  - Industry (academia) develops solutions
  - Agency provides funding (may require cost share)

HOWEVER…

- Other models exist and may help advance technology and/or share funding burden and/or accelerate commercialization opportunities
  - Federal -- state -- local -- industry
  - Federal inter-agency -- state -- industry
  - Federal inter-agency -- regional – industry
  - Private industry -- federal -- state
  - Others

SCRA Novel Technology R&D Partnerships

- **Model: Federal -- state -- local -- industry**

- Example: National Fuel Cell Bus Program
  - Federally-funded; cost share requirement of 50%
  - Customer: FTA
  - Partners
    - CTE (Atlanta-based non-profit)
    - Proterra (bus manufacturer)
    - University of South Carolina (demonstration site coordinator)
    - Central Midlands Regional Transit Authority (demonstration site operator)
    - SCRA (fueling infrastructure coordination)

SCRA

Proterra Bus Preparing to Fuel at Columbia Hydrogen Fueling Station, March 2009

Novel Technology R&D Partnerships

- **Model: Federal inter-agency -- state -- industry**
- Example: Fuel Cell Backup Power "Market Transformation" project at Ft. Jackson, SC
  - Federal / state co-funded
    - DoE $325K; SCRA $155K
  - Inter-agency agreement between DoE and DoD
    - Administered through Army Corps of Engineers Engineer Research and Development Center (Construction Engineering Research Laboratory)
    - Executed by ATI
  - Agreements structured to enable private partner (Logan Energy) the ability to capture federal investment tax credit for fuel cell equipment

Fuel Cell System Backup for Ft. Jackson Emergency Services Center, April 2009

Novel Technology R&D Partnerships

- **Model: Federal inter-agency -- regional -- industry**

- Example: Ft. Sumter Renewable Energy Project
  - Co-funded by two federal agencies (DoE, National Park Service)
    - Follow-on phases will leverage funding from state/local entities
  - Marries DoE H&FC “Market Transformation” program (focused on hydrogen/fuel cell technology) with NPS “Smart Parks” initiative (focused in this case on solar technology)
    - Administered through Army Corps of Engineers Engineer Research and Development Center (Construction Engineering Research Laboratory)
    - Project will be the first under DoE-NPS Smart Parks Initiative
    - Regional economic development group (Aiken, SC) partnered on the project and is contributing cost share
    - Executed by ATI

Planned Site for Ft. Sumter Renewable Energy Project, Fall 2010

SCRA Novel Technology R&D Partnerships

- **Model: Federal -- state -- private industry**

- Example: Landfill Gas – to – Hydrogen Production for Use in Industrial Material Handling Fleet
  - Host site: BMW Manufacturing Company (Greer, SC)
  - Funding sources:
    - US Department of Energy
    - SC Energy Office
    - SCRA (via SC Industry Partnership Fund, Hydrogen Infrastructure Development Fund)
    - Private foundation(s)
  - Project goals
    - Prove economic and technical feasibility of converting LFG to hydrogen
    - Demonstrate no adverse impact on long term fuel cell MHE performance using LFG-produced hydrogen
    - Support BMW decision to scale up to support entire MHE fleet (>400 pieces)

SCRA

BMW X5 and X3 Production Facility, Greer, SC

SCRA

Metrics of Success

Innovator Award for:

- outstanding initiative that encourages economic opportunities and quality of life relating to bio-products, alternative energy, and energy efficiency

- innovative use of technologies to promote energy efficiency; promotion of cross-industry collaboration; commercialization/technology transfer; preparation of workers for green collar jobs; and its replicability to other organizations or geographic areas

- collaborative partnership with the public, private, university, government and nonprofit sectors

Gov. Haley Barbour Presents Southern Growth Policies Board "Innovator Award" to SCRA CEO Bill Mahoney, June 2009

Wrap-Up

- **Ingredients for success:**
  - Supportive legislation (federal and state)
    - Sometimes geography matters a lot
  - Supportive regional / local communities
    - Often associated with research universities / institutions
  - Address the most pressing source of customer “pain”
    - Varies by geography and by target market
  - Collaboration and cooperation
    - Shared risks and rewards to create market demand (and market acceptance)

- **Hard realities:**
  - Federal funding availability (and priorities) can be unpredictable
  - State economic development construct biased against small, entrepreneurial companies (immediate job creation)
  - Competing technologies (including incumbent technologies)
  - Public perceptions (and mis-perceptions)

SCRA

Questions?

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Mobile Charging System

Joint Service Power Expo

May 3, 2011

Custom Manufacturing & Engineering, Inc.
3690 70th Avenue, Pinellas Park, FL 32781
T (727) 547-9799 F (727) 541-8822

www.custom-mfg-eng.com

OUTLINE

PROBLEM

- BACKGROUND
- REQUIREMENTS

DESIGN

- ELECTRICAL
- MECHANICAL

TESTING

- CME TESTING
- ATC TESTING

LUT

LESSONS LEARNED & SUMMARY

PROBLEM

In April 2009 CME was approached by PM-Soldier Warrior Ground Soldier (PM-SWAR-GS)

They needed to charge lots of batteries in 10 hours

Charging occurred in the field

Multiple types of of non-standard batteries

On some sort of mobile platform (vehicle, trailer)

Carrying about 10kW of DC power generation

PROBLEM

SOLUTION (almost)

CME had developed a mobile power platform several years ago called LPGP

Lightweight Power Generation Platform

It was a vehicle carrying 10kW of DC power generation

Club Car diesel 4-wheel drive off road utility vehicle converter to hybrid electric drive with wireless remote controls

PROBLEM

SOLUTION (almost)

LPGP with Ultralife chargers

Club Car with Ultralife chargers

BACKGROUND

PM-SWAR initially needed to charge Nett Warrior batteries, Ultralife LI-145 and LI-80

Not supported by CECOM

Over the next year requirements solidified slowly

More battery types were added

The numbers of batteries were determined

Additional needs were identified

REQUIREMENTS

- Vehicle; diesel, JP-8 fuel
- Charge 578 batteries in <24 hours
- Battery types, LI-145, Rifleman Radio, MBITR (Harris, Thales (BB-521-like))
- Storage for 578 charged batteries
- Power for 20 charges, 4 for LI-145, 16 for MBITR
- Company level charging with Platoon modularity with each charger removable for Squad use
- Standardized connectorization

REQUIREMENTS

- Auxiliary connectors for standard chargers
- Charge in all weather
- Carry fuel for one day’s operation
- Power distribution with protection
- Safety Assessment Report
- User’s Manual
- Training

DESIGN

Concept

Start with the Club Car, modify only as necessary

Add alternator

Add power distribution

Add safety controls

Add frame, canvas cover

Add removable racks

DESIGN

Work begins…..

by posing for pictures……or taking a joy ride

DESIGN

GFE Battery Chargers

Ultralife CH0012 for charging 12 LI-145 at once

Thales UBC for both MBITR and Rifleman Radio batteries for charging 8 MBITR or 16 Rifleman at once or a mix

ELECTRICAL DESIGN

- Mounted an MRAP 28VDC, 570A alternator under the bed coupled to the transmission
- Mounted and wired 4 NATO Slaves to alternator
- Built 4 intervehicular cables to connect each Platoon rack set (2 racks per Platoon)

ELECTRICAL DESIGN

- Designed power distribution panels for each rack

MECHANICAL DESIGN

Designed a rack with two configurations; 2 and 3 shelf

Telescoping shelves

MECHANICAL DESIGN

Racks latch onto rails mounted on bed

Chargers latch or thumbscrew onto shelves

MECHANICAL DESIGN

Designed and built a frame with hinged side panels

Covered the frame with canvas

MECHANICAL DESIGN

Designed and built three battery bag types for storage

TESTING

System Verification

Safety Assessment

ATC Evaluation

CME TEST

System Verification

Critical Tilt Angle

CME TEST

System Verification

Braking Distance

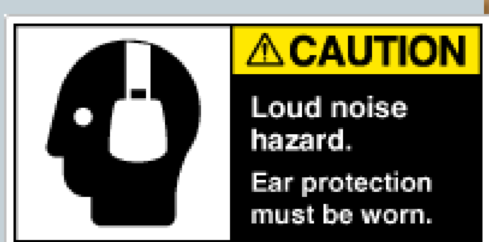
Power Distribution & Protection

ATC TESTING

- Inclinometer
- Brakes
- Safety Inspection
- Noise

ATC TESTING

Safety



ATC TESTING

The Safety Assessment Report and safety testing and inspection were completed

ATC signed off on the Safety Release allowing soldiers to use the MCS at the LUT

Without the Safety Release MCS would have been a static display

LUT

LIMITED USER TEST

Ft Riley, KS, November 2010

The Nett Warrior LUT included several sources for battery charging including fuel cells, thin film solar, small JP-8 generator and three vehicle-based charging systems.

Batteries included LI-145, MBITR (Thales and Harris), Rifleman Radio and conformal.

Charging took place in the field

LUT

LIMITED USER TEST

The MCS was driven by the team leader who followed behind the observers who followed the soldiers on a mission to take a village.

Travel was through thick brush, rutted open fields, high grass and paved road

After the village was taken, all the charging systems were exercised, including MCS, for an hour or so and then packed up and returned to base

LUT

LESSONS LEARNED & SUMMARY

Negatives

MCS was noisy, hearing protection required

MCS didn't look Army

There are materials we could use to reduce noise and we could couple the alternator to lower the rpm

We could have made it look more Army and although it would have been cosmetic there is something to be said for looks

For the limited time and budget….

LESSONS LEARNED & SUMMARY

Positives

MCS provided charging capability for a Company, Platoon or Squad

MCS provided a mule-like function

MCS can provide more power than was used or was made available

MCS did what it was asked to do without issue

LESSONS LEARNED & SUMMARY

Observations

The chargers took a long time to charge batteries, 6 to 7 hours versus 2.5 to 3 hours for C/2. That is 18 to 21 hours to charge a Company’s batteries

The load of 578 batteries per day every day seems like too much

There may not be a good answer to this problem except to need fewer batteries

THANK YOU

QUESTIONS??

The Quest for the Holy Grid

Presented by:

Ken Deylami

US Army, RDECOM, CERDEC, C2D, Power and Environmental Engineering

For:

2011 Joint Service Power Expo May 2-5

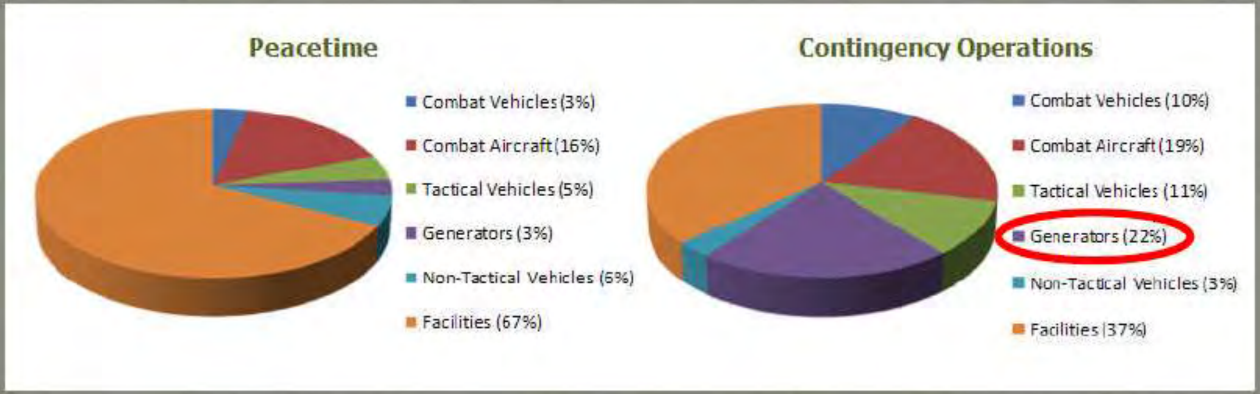
Introduction

• Ensuring power availability, Security, efficiency, quality and significant reduction in fossil fuel consumption are some of the goals DoD hopes to achieve to ultimately save energy and lives in theater.

"Army Energy Security Mission

Make energy a consideration in all Army activities in an effort to reduce demand, increase efficiency, seek alternative sources, and create a culture of energy accountability, while sustaining or enhancing operational capabilities"

• Power generators are the biggest fuel users during contingency operations



Introduction (Continued)

- In theater tactical trucks and transport aircraft use more fuel to transport fuel for the generators.
- Fuel convoys are vulnerable to insurgents attacks and life and equipment will be at risk for distributing fuel.
- In general the nation and DoD would like to be less dependent on fossil fuel particularly of the imported variety.
- All of the above has prompted DoD to embark on a "Quest for the Holy Grid", if there were such a thing.

The Basics

- Diesel generators run most efficiently at maximum capacity.
- In real life use they are mostly run at low/partial capacity hence inefficiently.
- The goal is to operated as few sets as possible at any given time for a given total load.
- This requires the right combination of sets, load sensing and intelligent generator control.

Solution Approaches

- Solutions range from very simple to very complex depending on many factors, mainly cost, time and application type.
- Application: For the DoD there are two types of application, Stationary and Mobile Tactical.
- Stationary applications are for large bases and installations, such as Fort Irwin, CA, 29 Palms MC Base, Fort Shafter HI,…….
- Mobile Tactical as the name implies is for mobile units where a different set of requirements come into play

Solution Approaches Continued

- Stationary systems usually include a regional grid tie. Also renewable energy sources are used where possible with the emphasis on fossil fuel use reduction.
- With Tactical Mobile systems the emphasis is on power availability, quality and system deployability (weight, Volume)

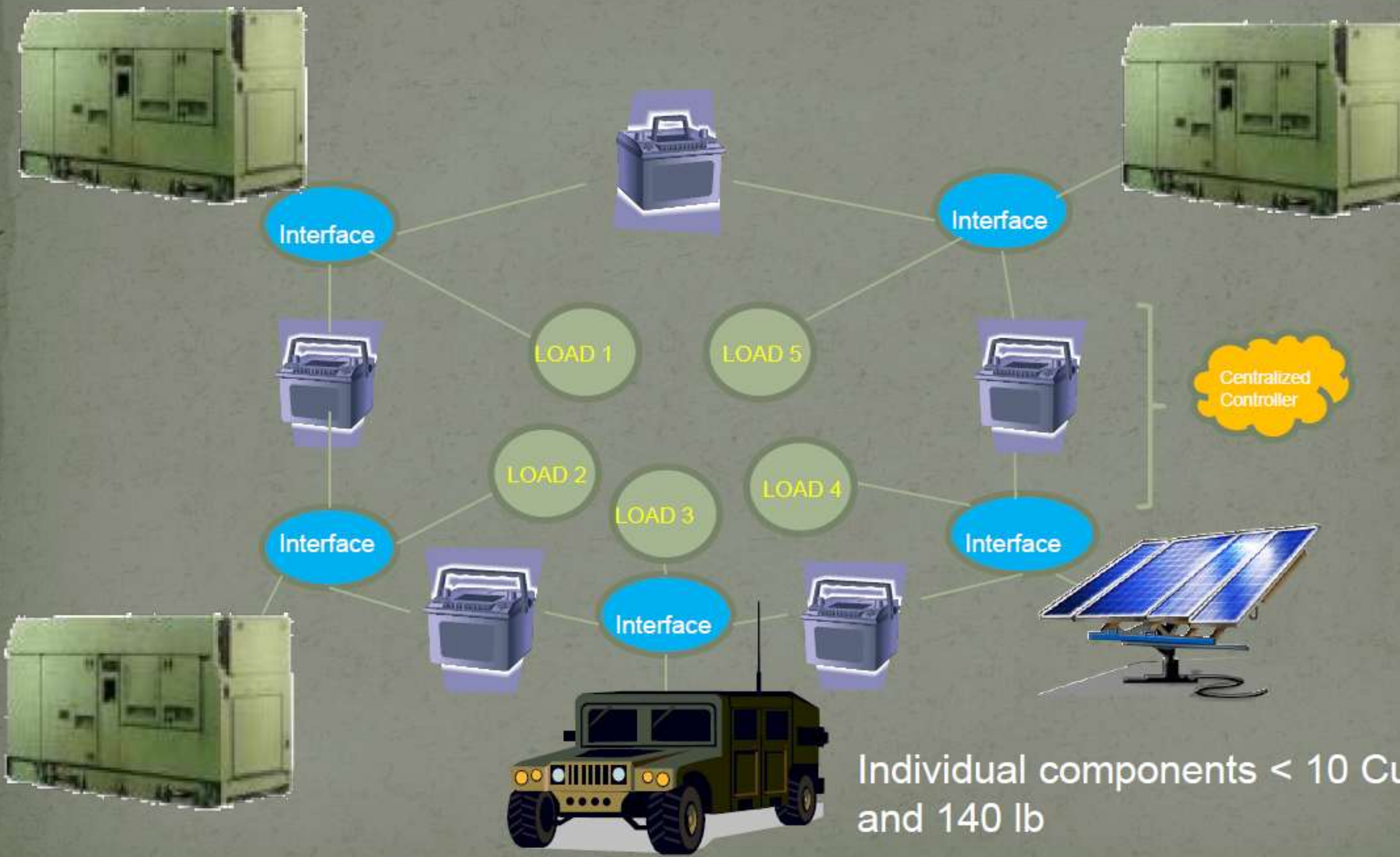
Solution Examples

Basic

- A good example of a simple yet effective Tactical Mobile grid is a setup with generators in sizes that allow a variety of total power output combination, automatic On/Off control boxes and distribution units. The below arrangement theoretically offers a load range from 4 kW to 140kW

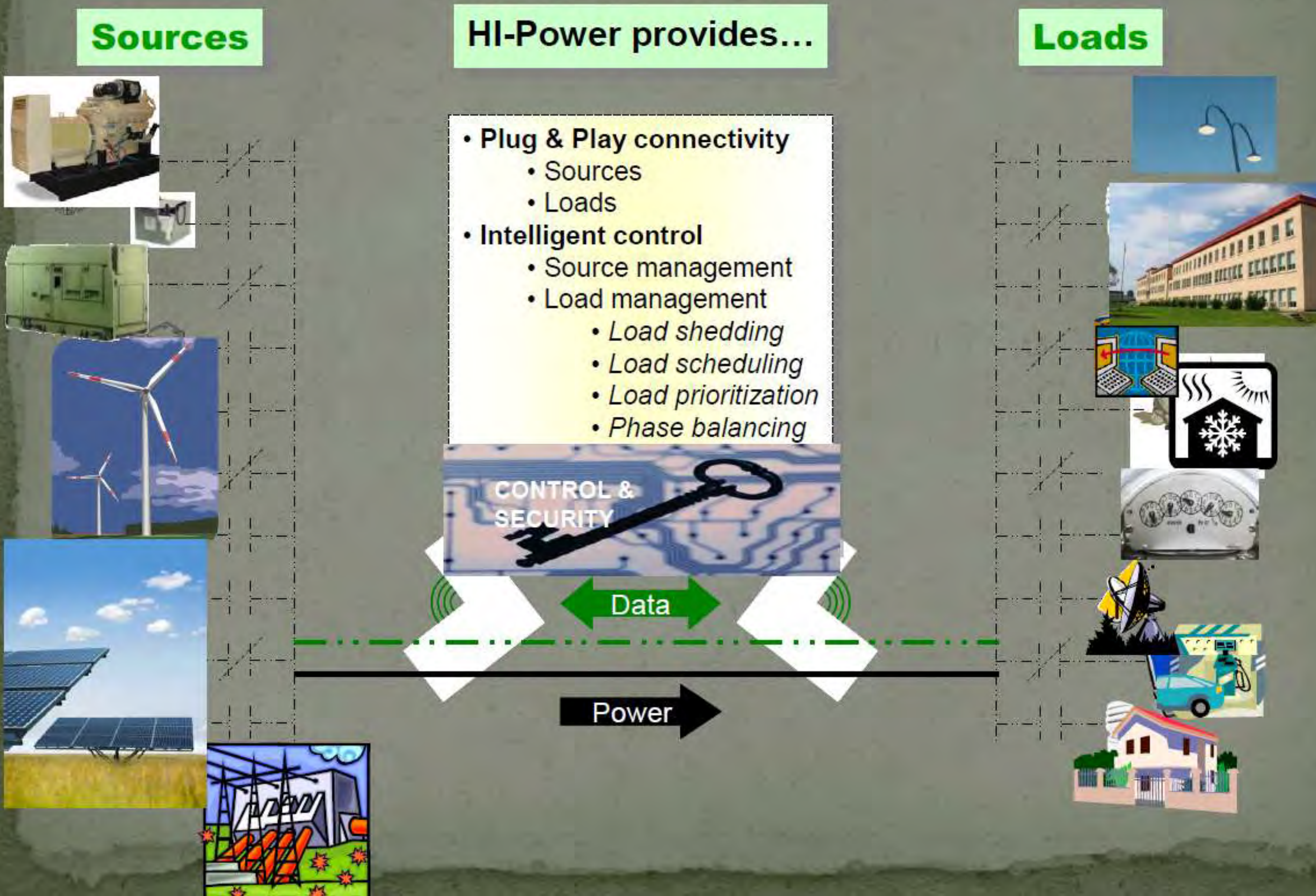
Solution Examples Continued

More Comprehensive



Individual components < 10 Cu Ft and 140 lb

Installation Set Up



System Diversity

- **EPPC** (Next Energy): 250kVA/500kVA system, integrated solar and wind <1kW , includes load prioritization and shedding , communication over Ethernet, has a very large package volume and weight (ISO container based), it is currently located at the National Training Center.
- Power Systems and Controls Microgrid (**PS&C**): Uses commercial off the shelf engine controllers, automatic identification of source via frequency keying, is very large and heavy (Container based), PV only supplies 460 VDC, no load controls or energy storage, currently at National Training Center.
- Basic Expeditionary Air Field Resources Smart- Microgrid System (**BEAR**-SMS) by Lockheed Martin: This Microgrid focused on renewable energy, synchronizing identical 750kW, 4160 VAC sets, is a fixed in place system, components are rated for 120kW, 208 VAC, 60 Hz, it incorporates load prioritization and shedding.
- **SCMG** (Smart Charging Microgrid by Honeywell): 250 kW at 480 VAC, uses solar sources (25 kW stationary and 10kW mobile) has utility connection, sheds load at overload conditions, incorporates vehicle to grid tie for 4 vehicles at 33kW total interface
- **PM FSS** demonstrator (L3 Communication and Electricore): This is a basic system comprising source TQGs with On/Off control, and distribution boxes. The system allows running the least number of sets for any given total load based on pre-set points selected by the user for their particular application. It does not include load control, renewables, vehicle interface or storage devices.

The Hybrid Intelligent Power (HI Power)

- The program started in 2008 as a 6 year $30 M R&D effort sponsored by the Office of the Secretary of Defense (OSD).
- To date several R&D contracts for system development and demonstration and studies have been awarded.
- Currently there are two on going Microgrid efforts developing intelligent tactical mobile grids, one due to complete in late FY 11 and one in mid FY12.
- Based on demonstration and testing of these systems and various studies to date a system would be specified and transitioned to the Product Manager Mobile electric Power (PM MEP) at Milestone B of the acquisition cycle.
- R&D will continue and new capabilities will feed into the Engineering and Manufacturing Development process (EMD).

HI Power Objectives

- Develop a standard, scalable, tactical Microgrid based a specific size Tactical Operation Center (TOC) that enables utilization and control of legacy and commercial power generation assets, renewable sources, vehicle power, and advance storage devices to:
  - Enhance tactical grid reliability, power availability and ultimately reduce logistics footprint and fuel consumption.

HI Power Challenges

- Hardware
  - Interfacing with low voltage DC sources
  - Interfacing with legacy generator equipment
  - Interfacing with sources of differing frequencies (50Hz, 400Hz… over the standard 60Hz)
  - Power Line Carrier or other communications solution
  - Size and weight of individual pieces and the overall system
  - Controls/Communications between units
- Renewable Sources & Energy Storage
  - Mobility of high power renewable sources
  - Energy storage requirements (Weight Size, operating temperature, life, capacity, recovery time, ability to handle transients….)
  - Types of energy storage necessary to achieve goals.

HI power Challenges

- Controls:
  - User Interface structure/information
  - Standard communication protocol
  - Controls/Communications between units
  - Source/load identification
  - Information Assurance
  - Firmware
  - Load management (prioritization/shedding)

The Holy Grid?

- Last count there were 24 Government sponsored and 9 commercially funded Microgrid programs.
- The collective knowledge gained from these efforts can be very valuable.
- To date no such knowledge base has been created.
- For DoD, Microgrids can be put in two categories:
  - Installation (Stationary) and Tactical (Mobile)
- Solution approaches for the above are very different other than the very basic requirements.

There is no "Holy Grid"

- There is no one solution to address all situations.
- In general running least number of diesel sets closest to their maximum capacity for any given total load provides the bulk of the fuel saving needed.
- Distribution and control (Software) coupled with maximum use of storage devices, solar and/or wind can ensure further reduction of fossil fuel consumption, power quality and availability.
- For tactical, mobile systems power availability, quality and system deployability are the predominant requirements.

Gen Set Eliminator System

NDIA Power Expo Conf

03 May 2011

Gen Set Eliminator Definition

- Eliminates the need for a second (back-up) Generator Set
  - Optimizes the function of a single Gen Set
  - Takes advantage of energy storage
  - Allows for power to be available when the Gen Set is off
  - Optimizes energy extracted from fuel

Present System Configurations

- Diesel gen-sets of various power levels
  - Present systems grown organically
  - Sized for peak power requirements but predominately run at low output
  - Low output means lowest efficiency
  - Always must be on
  - Works satisfactorily, but at high cost
  - Subject to high maintenance

Current System Problems

- Cost of energy is too high
- Supplying energy risks personnel lives
- Delivered Diesel fuel costs
- Local Electricity unreliable / non-existent
- Power Outages
- Lack of power source integration
- Power quality variability

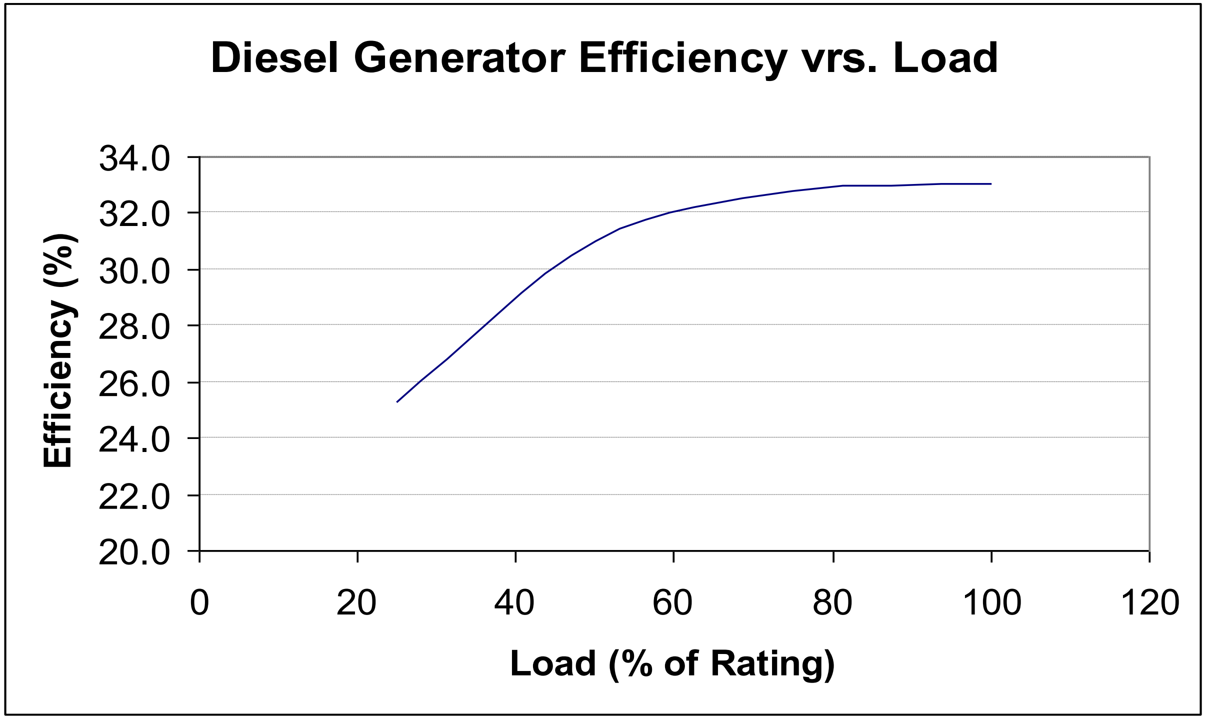
Desired Solutions

- Decouple Energy Generation from Use
- Reduce fuel consumption
- Utilize local and renewable sources
- Increase flexibility
- Reduce audible and thermal footprints
- Increase reliability
- Lighten load

Path Forward

- Increase efficiency
- Optimize
- Incorporate best methods
- Energy optimization with Storage

Typical Diesel Gen-Set



Diesel Gen-sets conversion rates of 25-33% are typical and are typically run at a low output and therefore their lowest efficiency, equates to highest fuel consumption per unit energy extracted

Energy Storage Operating Scenario

• Existing 1st Gen Set runs at higher efficiency

• Existing Gen Set runs when needed to meet load and to charge battery

• Existing Gen Set is shut off – and the energy is drawn from the battery

•Existing Gen Set is re-started and run as needed again to meet load / charge battery

Energy Storage Benefits

- Reduces Cost
  - 20 - 33% less Fuel consumption

- Integrates multiple power sources
  - Local power
  - Solar / Wind / FC
  - Intelligently controls power

- Quality
  - Eliminates switching power loss
  - Improves power quality

Energy Optimization with Storage

Towable "Gen Set Eliminator" Eliminates need for 2nd Gen Set

Existing Trailer and Gen Set

Gen Set Eliminator System

Preliminary Specifications

• Output Voltage (Typical)	208/120 VAC
• Master/Slave Capable	Yes
• Time on Battery (At Average Power)	3+ Hours
• Maximum Input Power	150KW
• Maximum Gen-Set Bypass	500KW
• Input Voltage (Nominal)	208 VAC
• Input Frequency	47-63Hz
• Temperature of Operations	-20 to +60C
• Environmental	Mil-Std 810F
• Onsite Communications	Integrated
• Monitor/Control channels	80
• Expandable	Yes
• Input/Output Efficiency (Double Conversion)	>80% Typical

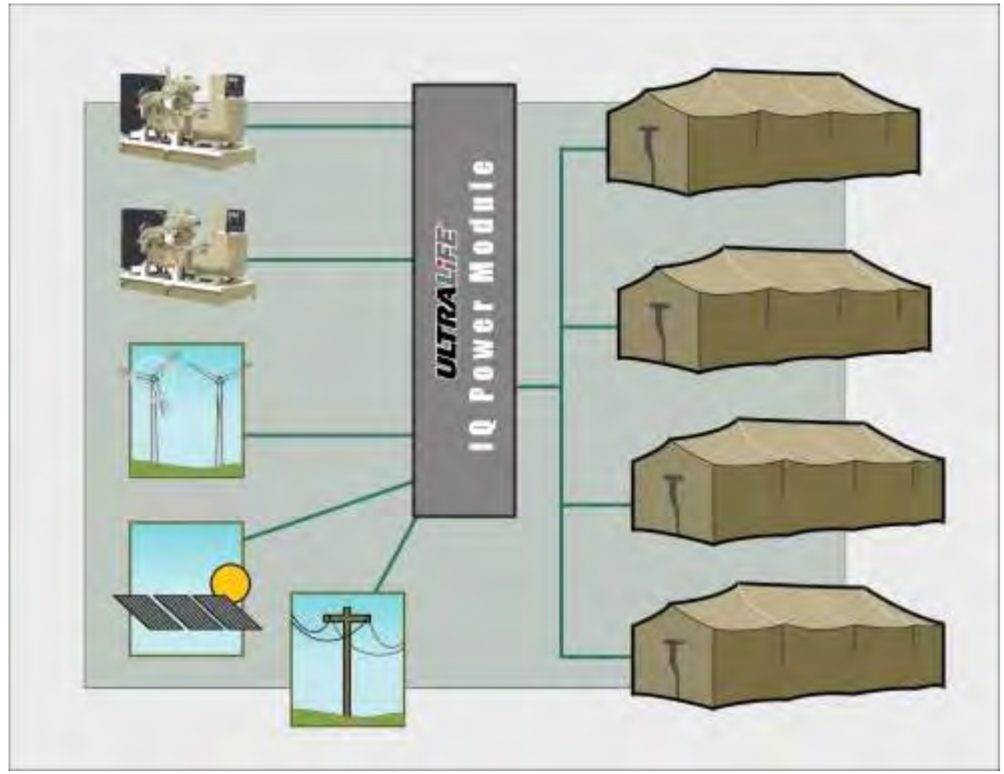
Subject to Change

Configuration Options

- Trailer mounted systems, with or without renewables
- Skid mounted systems, for Independent Energy
  - Solar Panels
  - Invertor/Rectifier
  - GenSet
  - Batteries
  - Battery development specific to application

Scalability of Energy Storage Systems

Ruggedized Power Module shown with integrated Solar Panels and Wind Turbines



System Detail - Programmable

Software Monitoring

Touch Screen Interface

Sources	
Gen-Set A	WindC
Gen-Set B	Solar B
Local AC	Fuel Cell A
Wind A	Fuel Cell B
Wind B	TBD
Solar A	TBD

Storage	
SOC	TAPL
Temps	Charge

Loads						
Critical 1	Critical 2	Critical 3	Critical 4	Critical 5	Critical 6	Critical 7
Primary 1	Primary 2	Primary 3	Primary 4	Primary 5	Primary 6	Primary 7
Secondary 1	Secondary 2	Secondary 3	Secondary 4	Secondary 5	Secondary 6	Secondary 7

Medical Tent

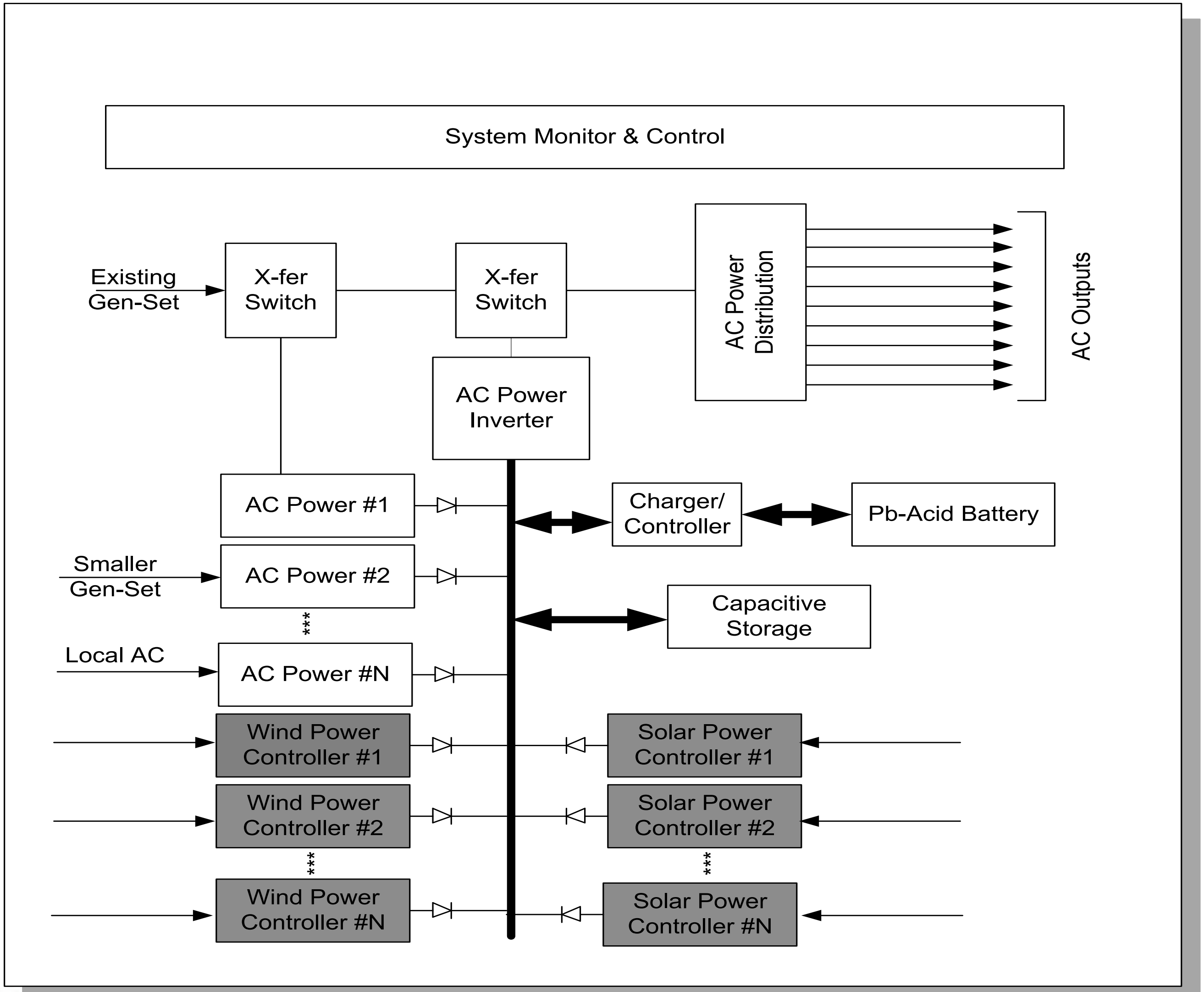
Guard Lighting

Comms Tent

Mess Tent

A/C Tents 1-5

Schematic Details

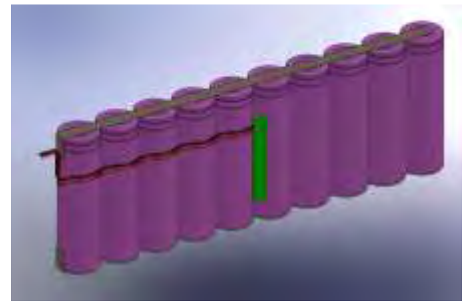


Batteries Type used for Storage

Standard Li-Ion Cobalt Oxide
Cylindrical 18650 cell before closing

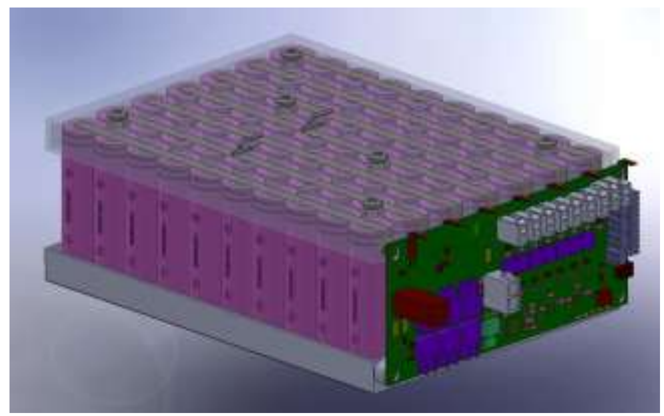
Li-Ion Battery – Building Blocks

Design Basic Cell String (10P)



Based on readily available
<u>mass</u> <u>produced</u> Li-ion
Cobalt Technology

Basic Brick 7S 10P



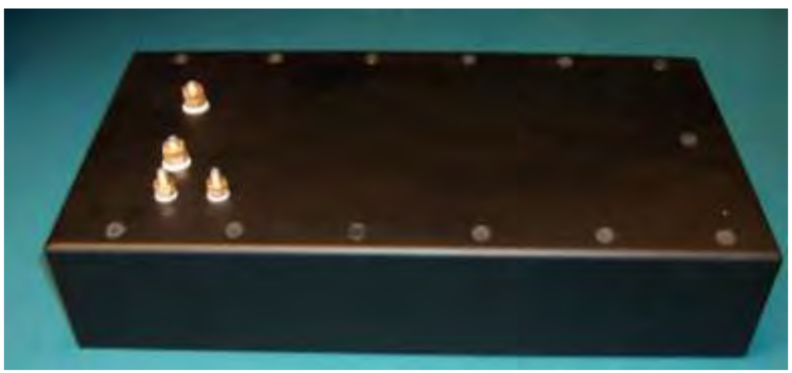
BRICK=
(70 Cells)

Shown With Integrated Monitoring and
Control Circuitry Designed and Assembled
by Ultralife

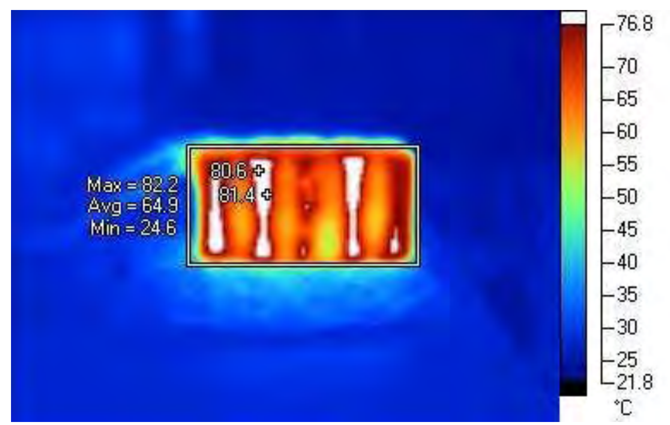
Testing and Qualification

- Circuit Board Design

- Cell Arrays (9S4P 26650)



- Custom Enclosures



- Full Diagnostic and
- Qualification Capability

Battery Configuration Options

Ultralife
36 volt, 30Amp, 24Ahr, 860 Whr
Cells: Panasonic, 18650, 2.4Ah
Pack: 10S10P packs

Ultralife
BB-2590 Li-Ion Battery
200 W-hrs

Energy Storage Advantages

- Power monitoring & control
  - Power generation management
    - Reduce diesel on time through energy storage
    - (Run diesel at higher efficiency for short time then shut off)
    - Select / Use / Store Renewable Energy Sources
  - Consumption management
    - Selectively shut down various users
- Power system monitored and managed
- Existing system remains available
- High power quality
- Reduced power outages
- Alternative energy source integrated
- Consolidated alternative energy sources
  - Standardized system configuration
  - Supply Power with no Noise
- Double conversion for power quality
- Battery backup eliminates power loss

Reduces Operating Expense with Better Power

- Reduction in Diesel Fuel consumption of 25-33% over a standard Diesel Gen-Set operated independently
- Fewer power interruptions - Built in UPS.
- Reduced Thermal and Acoustic Footprint.
- Silent operations with Electrical power intact.
- Reduced Operating Hours on Diesel Gen-Sets in use.
- Reduced Diesel Engine Piling due to more optimal loading.
- Improved system response to short term surge requirements.
- Scalable as required.

ultralifecorp.com

Thank You

Safety Release & Safety Confirmation Process

Perspectives on Rapid Fielding

(for NDIA Joint Power 2011 Expo)

Presented By:

D. Rusin LTC, (Ret.) & R. Lonardo LTC, (Ret.)
Dan.rusin@us.army.mil richard.lonardo@us.army.mil

Unclassified.
Approved for Public Release. 26 April 2011.

Purpose

To provide a brief overview of the DTC safety verification process,

and

To give the perspective of:

Government Tester

Government Rapid-Developer

(…to avoid surprises in the fielding process.)

How is This Brief Relevant to Me?

- Companies want to sell equipment to DOD!
- Most companies are addressing a need… or a perceived need.
- The government - organization buying it wants to provide solutions!
- We will use the case study and detailed ATEC information to help you further develop your project plan.

Unit Setting:

- “Delivery” DOES NOT EQUAL “Fielding”
- FIELDING (or Rapid Equipping) <u>includes</u>:

<u>Soldiers + Equipment</u>

+ Mission relevance

+ Training

+ Testing

+ Documentation

+ Designated “Recipient Unit”

+ Maintenance

(+ sometimes a helpful Catcher/Coach along the process)

The ARMY is PEOPLE. **(but a few persons do not represent the whole Army)**

Samples of items Involving Safety Confirmation.

Case Study Overview

- CENTCOM & RDECOM were sending a renewable energy system to AFG to conduct an operational assessment and ROI and provide this to the PM to help facilitate modernization strategies for tactical power.

Requirement
(Case study)

- **Operational Need:** Reduce Forward Fuel Consumption & Provide Tactical Power for Partners
- **Technology Provided:** NATICK assessed PowerFilm product as reliable and durable but didn't have a Safety Release
- **Operational Deployment:** Power Shade would be helo-transported to an enduring Combat Outpost (COP) for Soldier Assessment

Details

(Case study)

- ATEC testing would subject Solar Shade system to wind loads, electrical discharge safety, assembly, carry, durability, etc.
- RDECOM FAST paid for testing, and data was used to ensure product would meet rigors of the operational deployment.
- It does not pay to skip this step!

Safety Releases & Safety Confirmations:
Alert People to Hazards and Risks,
Identify Restrictions,
& Mitigations for Safe Use.

Assessment

(Case study)

Assessment
(Case study)




Results

(Case study)

Bottom Line: PowerFilm Power Shade demonstrated Safe performance, while provided power, in rain/wind environment.

Staking system <u>modified.</u> <u>Better</u> seals <u>applied</u> to Balance of System (BOS) electrical box to <u>eliminate water intrusion</u>

System granted "Safety Confirmation" and thus deployed on schedule to a Field Artillery Unit

What Was Learned
(Case study)

- CENTCOM
  - Must add cost and schedule for Safety Confirmation in technology program planning
- RDECOM/PM MEP
  - NATICK component had done its homework
- The Contractor: PowerFilm
  - Had a better understanding of Test Evaluation Mentality and how their product performed
- Down Range Deployment Managers
  - Confidence the technology was safe!

Safety Release

(AR 70-1, AR 73-1, DA-PAM 73-1, ATEC/DTC Reg 73-1)

- A Formal Document issued by DTC to a user/test organization **before** any hands-on testing, training, use, or maintenance by Soldiers
  - **Issued for a specific event**
    - **At a specified time**
    - **A specified location**
    - **Under Specified Conditions**
- Describes the specific hazards of the system based on
  - Test Results
  - Inspections,
  - System Safety Analysis
- Operational limits and precautions are identified to minimize risk to Soldiers
- All signed by Director, DTC.

• Does not authorize use of materiel in theaters where hostilities are present.
•Not intended to support materiel release decisions

• Information System Engineering Cmd, Army Network Enterprise Technology Cmd, Health Services Cmd and Medical Research and Development Cmd – Provide their own SR

Safety Confirmation

(AR 70-1, AR 73-1, DA-PAM 73-1, ATEC/DTC Reg 73-1)

- A Separate Document that provides the Materiel Developer and Decision Maker with DTC safety findings and conclusions
- The Safety Confirmation
  - Classifies Residual Hazards (Severity and Probability)
  - Uses the Approved Risk Acceptance Model
- Supports all Milestones, Type-Classification, Materiel Release, and Fielding decisions, or as requested.
- Provided to AEC for attachment to the ATEC Milestone Assessment Report (OMAR) or OTA Evaluation Report (OER)
- All signed by DTC Director

The S.C. Is NOT a Permission Slip.
SC describes risks and mitigations.

Safety Documentation Matrix

(DTC Pam 73-1)

Safety Release/Confirmation Matrix

Activity / DTC Document	Testing, Pre-Test Training, or Demonstrations Using Soldiers	MS B	MS C (LRIP)	Full-Rate Production Decision	Materiel Release Decision (Full or Conditional Training)	Urgent Materiel Release (UMR)	Interim Materiel Release	RFI/ REF/ ISE	System Changes (Modifications and Upgrades)
Safety Release	SR								
Safety Confirmation		SC	SC	SC	SC	SC	SC	SC	SC

Safety Release

- Issued for a specific event
  - At a specified time
  - A specified location
  - Under Specified Conditions
- Describes Safety Hazards & Operational Limits

Safety Confirmation

- Supports Milestones & Materiel Releases
- A separate document to AEC & Materiel Developer
  - Provides Safety Findings & Conclusions
  - Classifies any Residual Hazards

Supporting Documentation

- System Description
- Technical/Operational Manuals
- Safety Assessment Report
  - Prepared by PM or Prime Contractor
  - Include Software Safety Risk Analysis
- Health Hazard Assessment Report
  - Prepared by Public Health Command (Prov.)
- Government or Contractor Test Data

  Test Incident Reports

  Fault Tree Analysis
- DTC Test Center Recommendations support:
  - Safety Release Recommendation
  - Safety Confirmation Recommendation

RISK Acceptance Levels per DODI 5000.02, 8 Dec 08 Risk Assessment Levels & Definitions per Tables A-I thru A-IV of MIL-STD 882D, 10 Feb 00					HAZARD SEVERITY			
					Catastrophic	Critical	Marginal	Negligible
		Specific Individual Item	Fleet or Inventory		Could result in death, permanent total disability, loss exceeding $1M, or irreversible severe environmental damage that violates law or regulation.	Could result in permanent partial disability, injuries or occupational illness that may result in hospitalization of at least three personnel, loss exceeding $200K but less than $1M, or reversible environmental damage causing a violation of law or regulation.	Could result in injury or occupational illness resulting in one or more lost work days(s), loss exceeding $10K but less than $200K, or mitigatible environmental damage without violation of law or regulation where restoration activities can be accomplished.	Could result in injury or illness not resulting in a lost work day, loss exceeding $2K but less than $10K, or minimal environmental damage not violating law or regulation.
					1	2	3	4
HAZARD PROBABILITY	Frequent	Likely to occur often in the life of an item, with a probability of occurrence greater than 10^{-1} in that life.	Continuously experienced	A	1-A HIGH AAE	2-A HIGH AAE	3-A SERIOUS PEO	4-A MEDIUM PM
	Probable	Will occur several times in the life of an item, with a probability of occurrence less than 10^{-1} but greater than 10^{-2} in that life	Will occur frequently	B	1-B HIGH AAE	2-B HIGH AAE	3-B SERIOUS PEO	4-B MEDIUM PM
	Occasional	Likely to occur some time in the life of an item, with a probability of occurrence less than 10^{-2} but greater than 10^{-3} in that life	Will occur several times	C	1-C HIGH AAE	2-C SERIOUS PEO	3-C MEDIUM PM	4-C LOW PM
	Remote	Unlikely but possible to occur in the life of an item, with a probability of occurrence less than 10^{-3} but greater than 10^{-6} in that life	Unlikely, but can reasonably be expected to occur	D	1-D SERIOUS PEO	2-D MEDIUM PM	3-D MEDIUM PM	4-D LOW PM
	Improbable	So unlikely, it can be assumed occurrence may not be experienced, with a probability of occurrence less than 10^{-6} in that life	Unlikely to occur, but possible	E	1-E MEDIUM PM	2-E MEDIUM PM	3-E MEDIUM PM	4-E LOW PM

Follow-up

DTC POC:

ATEC
http://www.atec.army.mil

DTC "Request For Test Services" RFTS:
https://adss.atec.army.mil/Public/RFTS/TestRequests/Request.aspx

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DTC Test Manager
TEDT-TMA
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APG, MD 21005
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BACKUP

System Commodity Areas Tested At DTC Ranges

Direct Fire
Live Fire
Vehicles
Small Arms
Gen & Indiv Eq

Air Systems
Air Worthiness

Missiles
Ballistic Msl Def

Small Missiles
& Rockets
Guidance Sys
HE Warhead
& Fuzes

Chem Bio
NBC Surviv
Smoke &
Obscurants
Methodology

Indirect Fire
Air Delivery
Air Armaments
Vehicle/Support Equip
Imp Explosive Dev

C4I
Info Assur

SAFETY ASSESSMENT REPORT (SAR)

- Formal summary of safety and health data collected during the life of the system. Provides hazard potential and corrective actions to avoid personnel injury and equipment damage during testing.

- Includes The Surgeon General's (TSG) Health Hazard Assessment (if available).

- PM Responsibility.

- To be provided 60 days prior to the start of DT/OT testing/demonstration:
  -- Facilitates SOP preparation
  -- Provides focus to safety testing

HEALTH HAZARD ASSESSMENT (HHA)

- The application of biomedical and psychological knowledge and principles to identify, evaluate, and control the risk to the health and effectiveness of personnel who test, use, or service Army systems.

- Prepared by The Surgeons General's (TSG) Office at customer request.

- Based on the following:
  - -- User provided data
  - -- Previous testing
  - -- CHPPM studies (Ionizing/Non-Ionizing radiation, toxic fumes)
  - -- Other TSG collected data.

- HHA Requests electronically submitted via the Public Health Cmd.

2011 JSPE - Saft

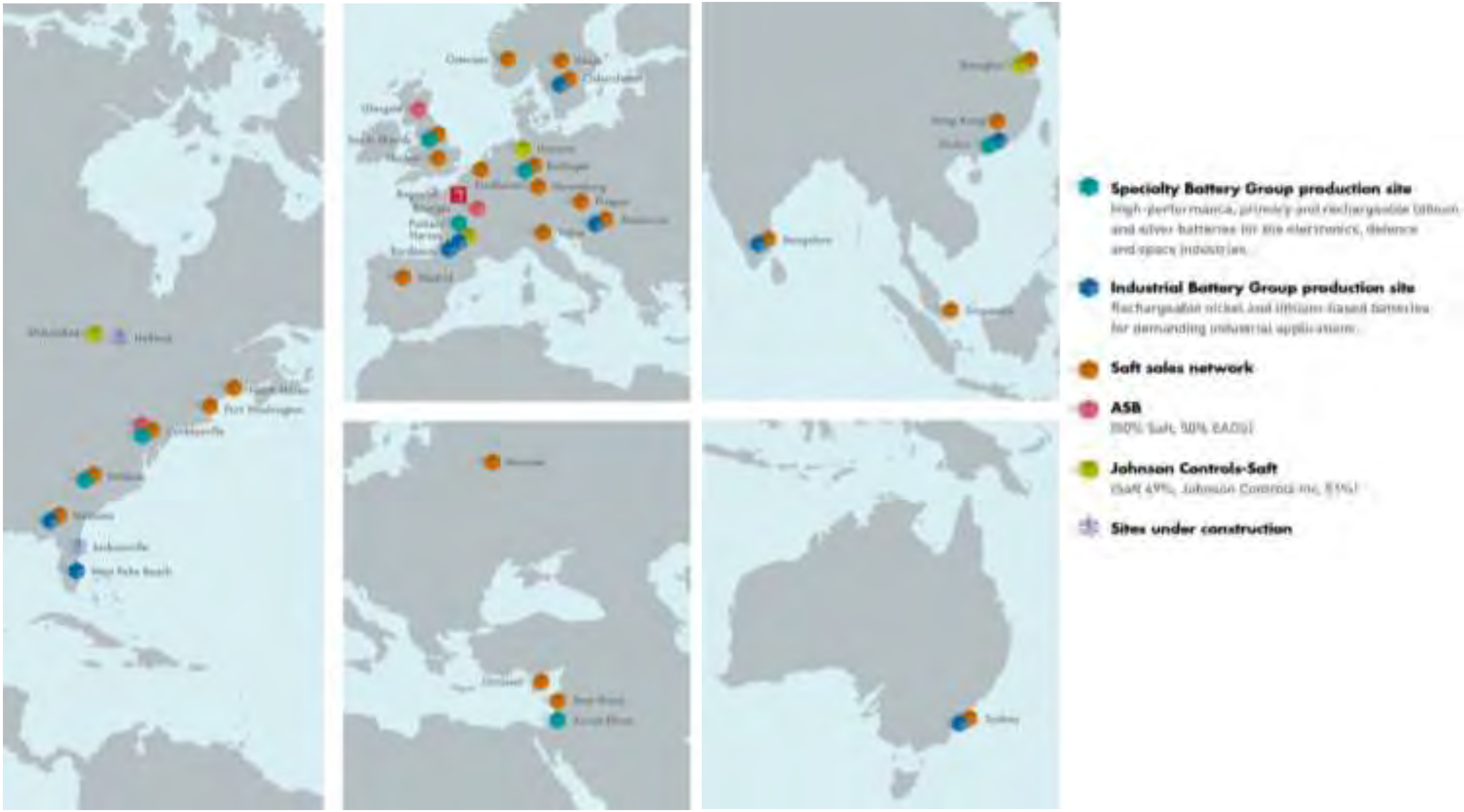
Advanced Lithium Power Sources – Squad Power

4 May 2011

Squad Power – Key Topics

- Saft Background
- Improved Target Acquisition System - Lithium Battery Box
- Battery Life
  - > Expectations vs. Experience
- Fielded Lessons
  - > Expecting the Unexpected
- Energy Storage on the Grid
- Squad Portable Storage
  - > Central hub for energy
- Platform Mounted Storage
  - > Integrating at a higher level

An International manufacturing network close to its customers



Jacksonville project update

- Contract signed with Department of Energy
- Factory construction contract signed
- Official ground-breaking ceremony held March 15th, 2011
- Over 350 MWh plant capacity by 2015 with room for further expansion
- Start of production H2 2011

Jacksonville Building Progress (as of January)

Space and Defense Division, Cockeysville, MD

Dedicated to manufacturing advanced Li-ion cells and batteries for Space and Defense applications

Type of Cell	VL4V	VL12V	VL22V	VL34P	VL52E
	Very High Power			High Power	High Energy
Dimension					
Diameter (mm)	34	47	54	54	54
Case length (mm)	156	152	174	174	200
Mass (kg)	0.33	0.64	0.96	0.94	0.99
Capacity (Ah)	5.5	12	22	33	52
Specific Energy (Wh/kg)	50	74	84	120	200
Energy Density (Wh/L)	138	175	200	280	430
Power (W/kg) 18 sec pulse at 50% SOC	3600	6000	6350	1900	N/A
Continuous Discharge Rate	60C	100C	100C	15C	1C

Improved Target Acquisition System (ITAS)

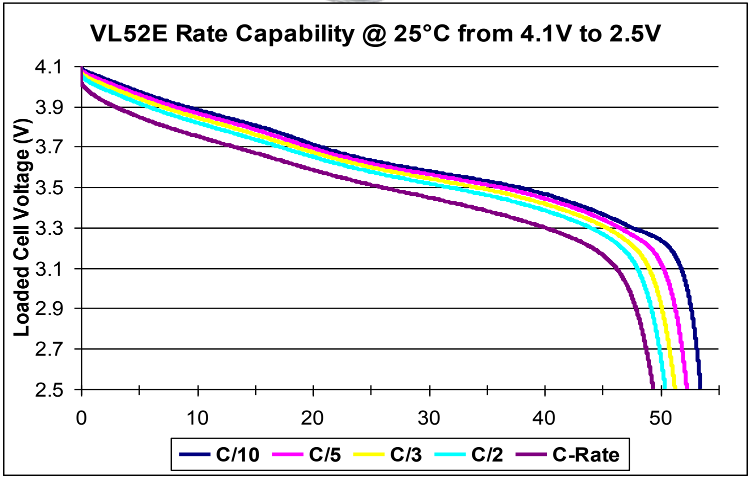
- Saft supplies the battery for Raytheon’s Improved Target Acquisition System used with the TOW Missile.
- Battery powers weapon sight / targeting unit (ITAS)
- More than 3000 batteries have been fielded for combat use. Systems in Iraq and Afghanistan (TRL-9).
- Raytheon has recognized Saft with the Supplier Excellence Award five years in a row due to our performance on this program.

ITAS – Lithium Battery Box

- Production began in 2004 – the first production for a large Lithium-ion system.
- Improvements over former AgO/Zn technology:
  - > Increased Operational Readiness
    - No activation charge needed
  - > Charging time < 6 hours
  - > Operating time > 16 hours
  - > Total life > 5 years
  - > Reduced service cost
- Only required field maintenance is periodic charging
- Battery specs:
  - > 28 V, > 100 Ah
  - > 65 lbs
  - > Energy = 2.5 kWh

ITAS cell pack: 8S, 2P configuration

ITAS - High Energy Cell Design



Characteristic	Units	Value
Mass	kg	1.0
Volume	L	0.48
Charge Voltage	V	4.1
Capacity (4.1V-2.5V, 25°C, C/7)	Ah	52
Specific Energy (4.1V-2.5V, 25°C, C/10)	Wh/kg	185
Energy Density (4.1V-2.5V, 25°C, C/10)	Wh/L	385
Peak Discharge Current (RT, Complete)	A	52
1kHz AC Impedance	mΩ	0.8
Terminal-to-Terminal Length	mm	208
Diameter	mm	54

VL 52 E

ITAS - Battery

- Robust
  - > Shock
  - > Vibration
  - > UN Transportation
  - > Waterproof to 36” but floats
  - > EMI, EMC, NBC qualified
- Designed for one man lift
- Ergonomic Connector access
- Simple user interface
- Designed for 36” drop cold
  - > 32 drops for qual – no leaks
- Made to fit the space in HMMWV behind passenger seat

ITAS - Flange Panel Front Controls

- Two Mil spec connectors with connector covers
- BIT lights (BAT, ELEC)
  - > BAT = Cell Pack
  - > ELEC = Electronics
- Display Intensity Control
  - > On (low) / On (high) / Off
- Charge Indicator
- State of Charge LEDs
- Power Switch integral 35A Circuit Breaker
- Override Switch

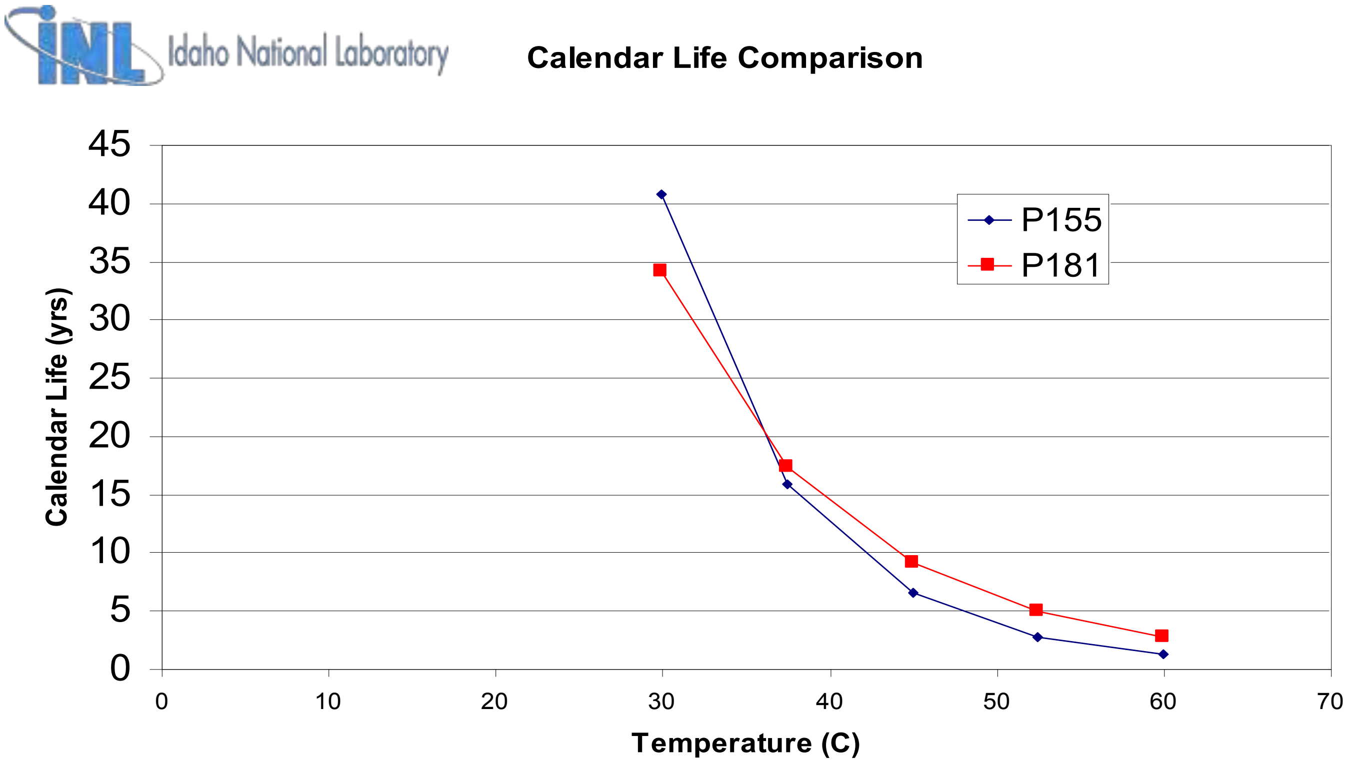
Battery Life

- Battery life based on few major factors
  - > Fundamental Electrochemistry – Specific chemistry gives life potential
  - > Calendar Time / Temperature – Lower temperature gives longer life
  - > Discharge Depth and Rate – Shallower / slower cycles give longer life
- Methods to determine life take time – cycles and calendar time
- Two data sources – Lab / Field

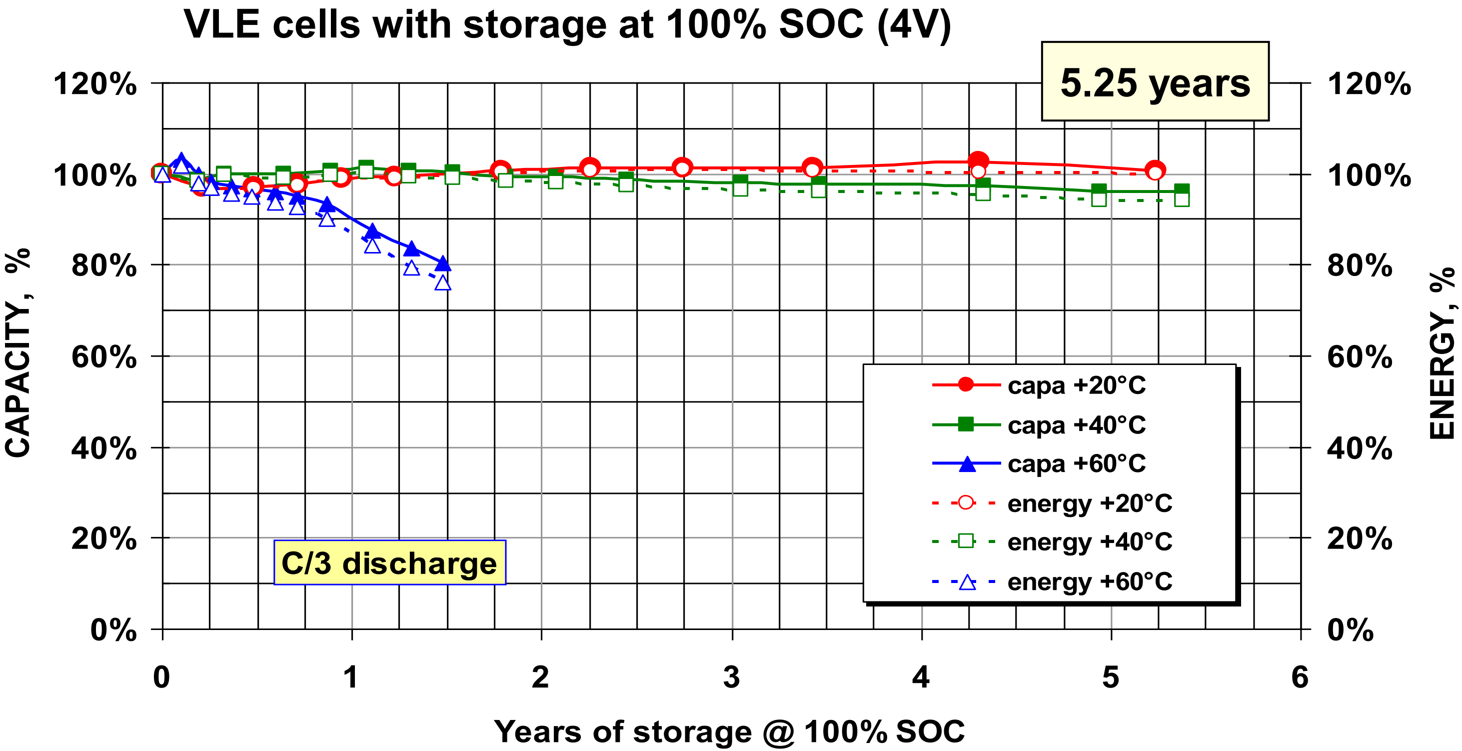
Battery Life - Definitions

- Battery life defined for given application
  - Typically when battery delivers 80% of new capacity
- Lithium-ion - General Life / Technology
  - No memory effect as in some other chemistries
  - Does have low rate self discharge
  - Self discharge will vary from cell to cell
  - Overcharge is chief systems concern

Battery Life - Saft Lithium Ion (NCA)



Battery Life - Calendar Stability at Temperatures

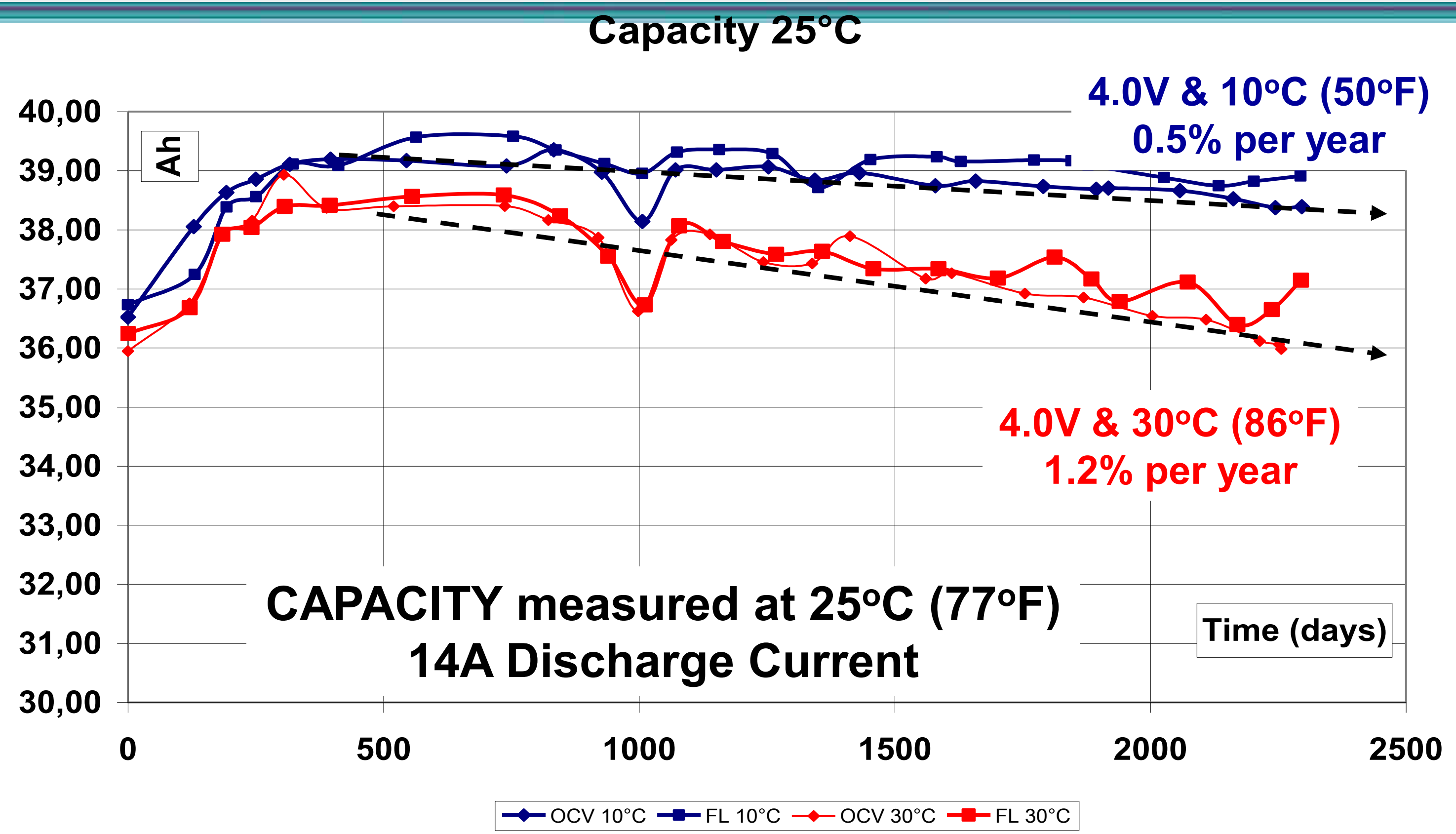


Battery Life - VES140 Cell for Space

- Space program calendar life testing of Li-ion cells
  - > Cells were very similar to ITAS cells
- Actual > 6 years of storage performed
- Storage done at several different voltages and two different temperatures – 10°C and 30°C on float and on Open Circuit Voltage
- Capacity and impedance measured periodically

Storage Condition	Capacity Loss per Year	Remaining Runtime after 10 Years (20 hours at start)
	Based on 6.8 years testing	Best Estimate Projection
4.0V and 10°C (50°F)	0.5%	95% / 19 hours
4.0V and 30°C (86°F)	1.2%	88% / 17.6 hours

Battery Life - VES140 Cell for Space



Battery Life – Fielded Batteries

- Batteries SN0064 and SN0187 tested at Saft after 3+ Years uncontrolled use (transit, operational use, etc)
- Battery Capacities were 90.7 Amp Hours and 93.3 Amp Hours
  - > Battery test
    - ITAS simulation discharge at room temperature (C/18 rate)
    - Capacities were above nameplate capacity for new units
  - > Original Cell Capacities were checked
    - Manufacturing data from July and December 2004.
    - Capacities were roughly 45 Amp Hours at medium discharge rate (C/3 rate) – Equivalent to 90 Amp Hours in a battery
- Very low capacity loss after 3+ years uncontrolled use – Roughly 3% in July 2004 unit / No loss in December 2004 unit

Battery Life – Limiting Factors

- Electrochemistry – Not the limiting factor?
  - > Life of more than 7 years (and counting) demonstrated
- Connectors – Mate / Unmate Cycles
  - > Expected number of cycles for MIL-38999
- Interior Components – Foam / Adhesives
  - > Degrade over time
- Physical Abuse
  - > Case damage
  - > Lack of charging

Fielded Lessons – Alternate Uses

- Supporting the Warfighter!

Warfighter

ITAS LBB (in supporting role)

Fielded Lessons – Systems Function

- ITAS LBB contains complete system functionality
  - > Overcharge Protection (Primary Function)
    - Multiple Layers
    - Fully independent circuits
  - > Cell Balancing
  - > Communication with maintainer
- Lesson: Overcharge protection has been a complete success
  - > No failure – ever!
- Once circuit is in place, what other features can be enabled?

Fielded Lessons – Logistic Challenges

- Battery Charging
  - > Only maintenance needed!
  - > Once every 6 months
    - Baseline recommendation
    - Consult Raytheon FSR's for best practice
  - > Lesson: Lead cause of battery return
- Cell Balance
  - > Handled by LBB system
  - > Lesson: Challenge for battery availability
- Solution – Training and Setting Expectations
  - > Article in "The Preventive Maintenance Monthly" (August 2008)
  - > Sharing current information

Fielded Lessons – Logistics - Charging

- Batteries self discharge over time and ensuring a maintenance charge is applied remains a challenge.
- Largest return issue (by far)
- Education of user has helped
- Continued storage at low SOC can lead to irreversible cell damage and require cell replacement

Fielded Lessons – Battle Damage

- Enemy Fire
  - At least five batteries in separate incidents
  - Batteries smoked, vented
  - Not the end of the world!
- Overwhelming Damage
  - Bridge collapsed onto one battery

Renewable Energy - Commercial

	Grid level	Demand side
Centralized	■ High power Energy Storage ▪ Smoothing / Ramping support ▪ Grid stabilization/Power Quality ▪ Ancillary services ■ Bulk energy storage ▪ Energy dispatching ▪ Avoid disturbances ▪ Defer grid upgrades ABB Solar Farms	■ Commercial Storage ▪ Peak Shaving to avoid demand charges
Distributed	■ Smart Grids ▪ Controlled energy flows between decentralized generation and grid Guadeloupe	■ Smart Consumption ▪ Self-consumption ▪ Zero-energy houses ▪ Safe against outages ▪ High efficiency Sol-ion Apollo

Renewable Energy - Military

	Grid level	Demand side
Centralized	■ High power Energy Storage ▪ Smoothing / Ramping support ▪ Grid stabilization/Power Quality ▪ Ancillary services ■ Bulk energy storage ▪ Energy dispatching ▪ Avoid disturbances ▪ Defer grid upgrades ABB Solar Farms Installation	■ Commercial Storage ▪ Peak Shaving to avoid demand charges
Distributed	■ Smart Grids ▪ Controlled energy flows between decentralized generation and grid Guadeloupe FOB	■ Smart Consumption ▪ Self-consumption ▪ Zero-energy houses ▪ Safe against outages ▪ High efficiency Sol-ion Apollo Squad / FOB

Renewable Energy – Military / Squad Power

	Grid level	Demand side
Centralized	■ High power Energy Storage ▪ Smoothing / Ramping support ▪ Grid stabilization/Power Quality ▪ Ancillary services ■ Bulk energy storage ▪ Energy dispatching ▪ Avoid disturbances ▪ Defer grid upgrades Installation	■ Commercial Storage ▪ Peak Shaving to avoid demand charges (avoid inefficient use of costly fuel) FOB
Distributed	■ Smart Grids ▪ Controlled energy flows between decentralized generation and grid (size generation to load) FOB	■ Smart Consumption ▪ Self-consumption (renewable) ▪ Zero-energy (reduced fuel need) ▪ Safe against outages (mission) ▪ High efficiency Squad / FOB

Advanced Lithium Power Source

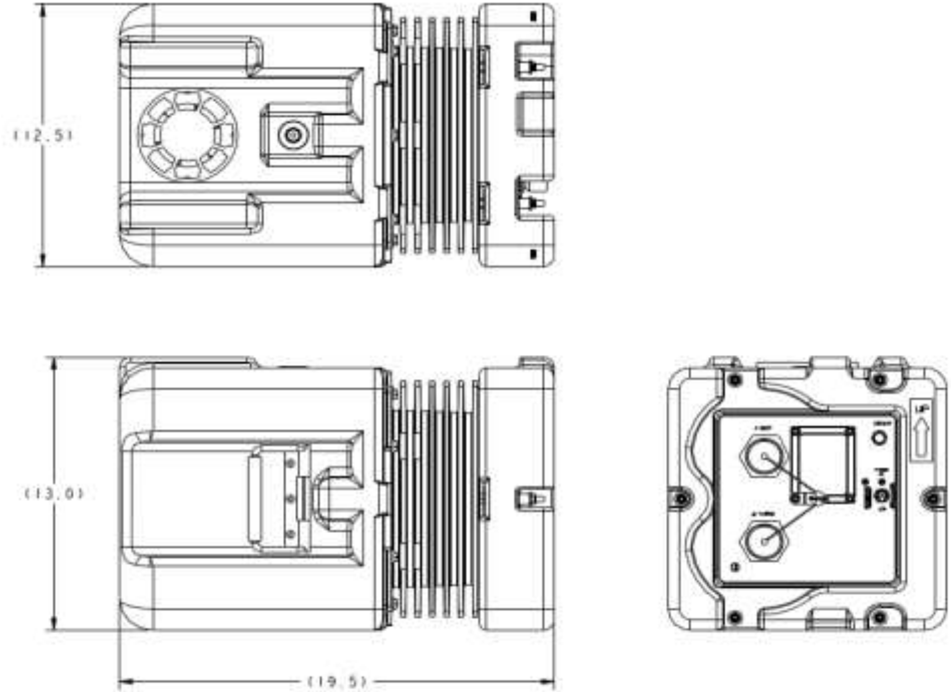
- Development from the ITAS LBB – Performance Heritage
- On board AC and DC charging – Convenient Charging
- Lower Voltage range
- Wider variety of applications – Simple integration

- Available Now!

28

Physical Configuration

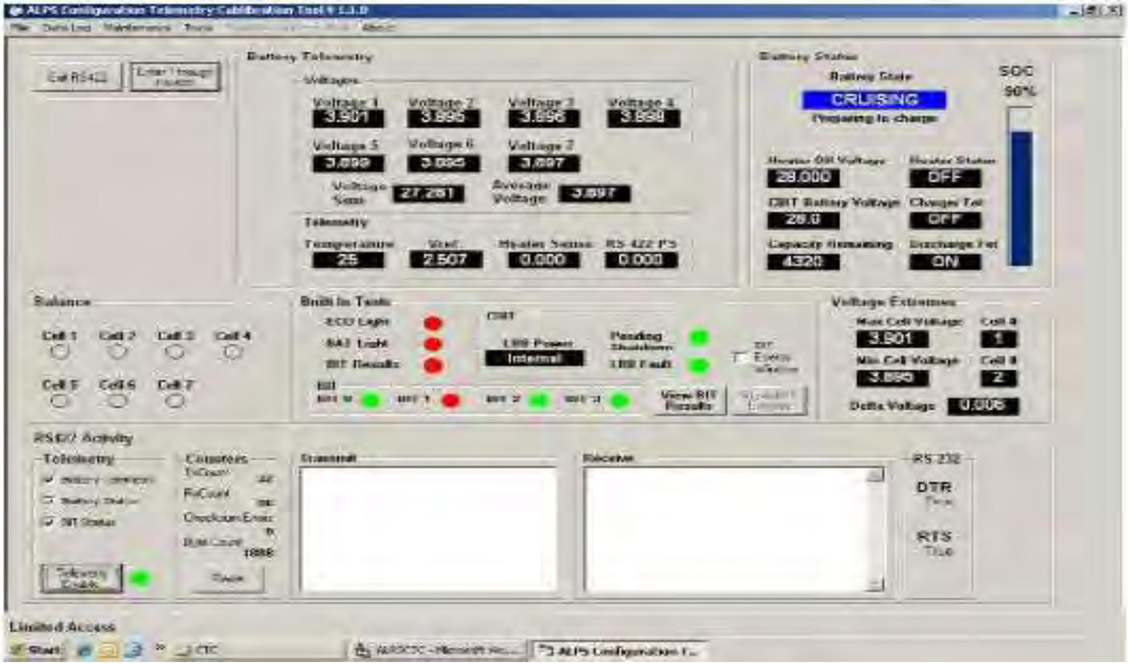
- Dimensions:
  (inches)



Discharge / Charging Options

- DC Output
  - > 30 Amp circuit breaker protected
- AC Input
  - > AC input can vary – 110/220V
  - > Less than 10 Amp draw at 110V
- DC Input
  - > Connects to 28V Nominal MIL ground vehicle bus
  - > Uses bus voltage to determine when to charge
    - only when engine operational
  - > Accepts up to ~10 Amp charging energy

Data / System Graphical Interface Tool



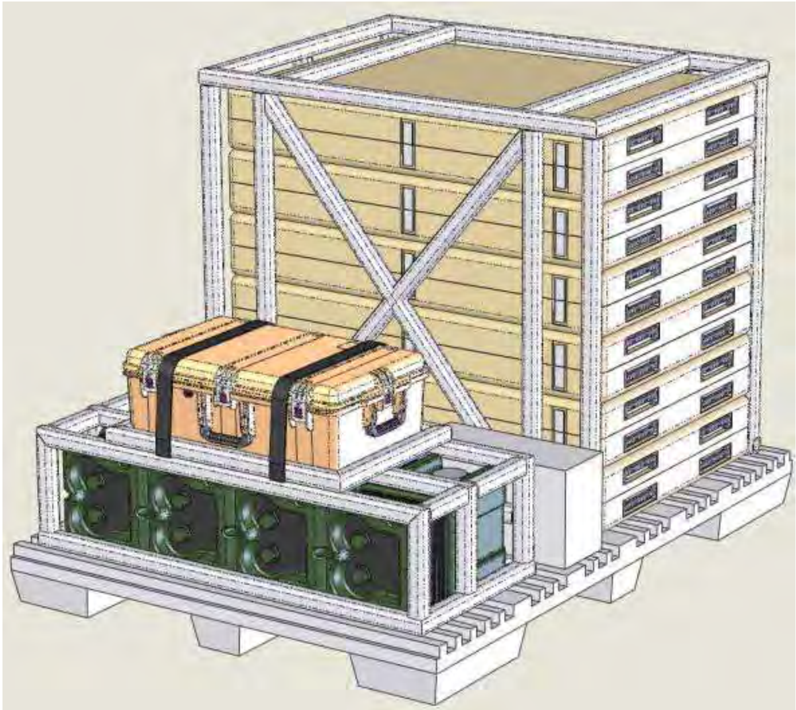
- Tool allows detailed view of battery status
- Data available over RS-422 bus – Integrates with higher level platform

ALPS Key Attributes

- Life Cycle Cost
  - > Proven technology outlasts BB2590 by factor of 10
  - > Proven calendar life 7 years and counting …
- System Simplification
  - > AC / DC Charging all in one box – No complicated cabling
- Rugged for Field Use
  - > Uses proven housing / durable design
  - > Proven simple state of charge gauge and interface
- Enhanced operational profile
  - > 2.6 kWHr
  - > Longer mission run time

ALPS – System Component

- ALPS – Part of System
  - > Integrates to renewables
  - > Man-portable
  - > Communicates with large system
    - Control of energy flow
    - Interface with user



  - > Image courtesy of Iris Technology Corporation

Energy Storage Value Chain

Fuel/Energy Sources → Generation → Transmission → Distribution → Electricity Customers

Energy Storage

Renewables Capacity Firming

Smoothing, Ramping

Energy & Power

Ancillary Services

Transmission Stability

High Power

Load Management

Peak Shaving

Energy & Power

Time Shifting

Energy

Conclusions

- Saft’s High Energy Technology is ideal for use in deployed situations as a high reliability power source.
  - > The robust cell design allows for high charge and discharge power, low heat generation, and excellent cold temperature performance, all with extended cycle and calendar life.

- Saft’s System approach and integrated control electronics provide an unsurpassed total solution for today's field demands
  - > 100% performance of charging safety system has been a key success.
- Large Format Lithium-ion batteries are a success in today’s battlefield!

Conclusions (continued)

- Saft would like to thank US Army Close Combat Weapons Systems (CCWS) and Raytheon for their continued support and team based approach in providing the best possible power solutions for the US Military.
- Saft would also like to thank our customers for continued feedback on battery system performance. This insight allows us to continually update and improve our energy storage solutions.

Questions?

Contact Information

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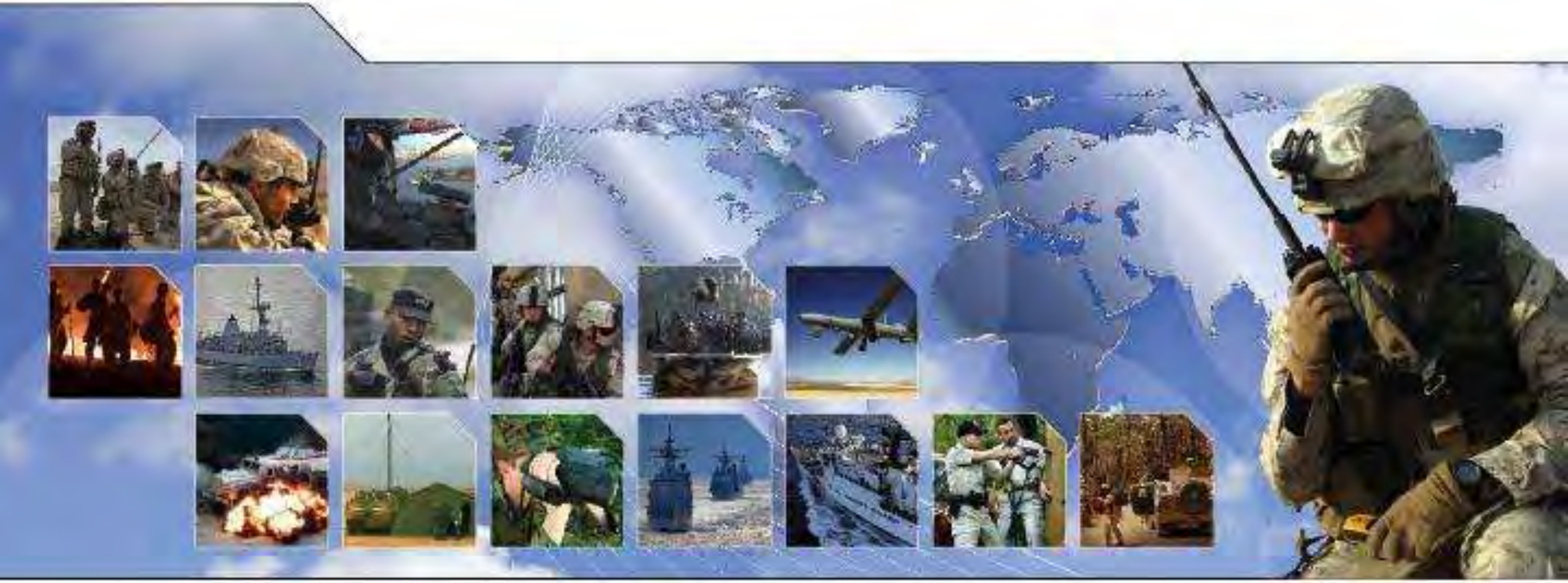


Thales Light Weight Smart Battery (LWSB)

Thales- Introduction

Thales Battery-powered Portable Products

LWSB Battery Concept

Lithium Ion Cell Capacity Trends

Increased Use of Soldier Wearable Batteries

LWSB Benefits

Applications

Test and Evaluation

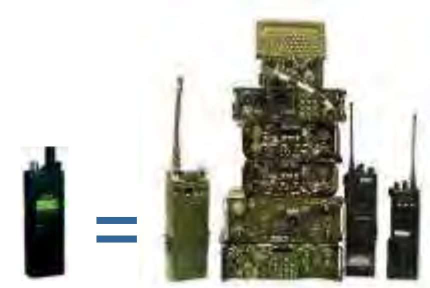
Questions

THALES

Overview

What We Do:

- Pioneer new concepts and lead in the development, manufacture, and support of battle-proven, software-defined radio equipment around the globe



60 lbs of communications equipment down to 2 lbs

- Leverage our expertise in size, weight, and power (SWAP) constrained battlefield environments into adjacent domains:
  - Handheld/Soldier Military Radios
  - Handheld Public Safety Radios
  - Vehicle Radios and Accessories
  - Airborne Systems
  - Shipboard HF Communications Equipment

- Play key role in the Joint Tactical Radio System (JTRS) Programs of Record:
  - JEM/CISCHR
  - Handheld, Manpack, and Small Form Fits (HMS)
  - Airborne, Maritime, and Fixed Site (AMF)
  - Multifunctional Information Distribution System (MIDS-J)

THALES

Our Customers:

- We serve:
  - U.S. Department of Defense
  - U.S. Department of Homeland Security
  - U.S. Civilian Agencies
  - Allied and Coalition Forces Globally

- With technology developed and produced in the U.S. and supported around the world

Our Locations:

- Headquartered in Clarksburg, Maryland, just 45 minutes from our nation's capital
- Four U.S. facilities
- In-theater locations supporting warfighters in Kuwait, Iraq, and Afghanistan
- Plus, customer maintenance depots established across the U.S

Headquarters – Clarksburg, MD

Clarksburg, MD

Germantown, MD

Clarksburg, MD

Kuwait

Handheld Radios

Liberty™ Multiband LMR
Public Safety

AN/PRC-148 JEM
Tactical

AN/PRC-154 Rifleman
Tactical

AN/PRC-148 Rechargeable Battery Solutions

- Thales has produced more than 200,000 AN/PRC-148
- Thales offers two batteries for AN/PRC-148 radio
  - Standard 4.8AH battery
  - New High capacity 5.8AH battery
- Both batteries are compatible with all released charger accessories and vehicular systems
- In the field, users are using AN/PRC-148 rechargeable batteries with a competitor product
- AN/PRC-148 rechargeable batteries have been licensed to a number of other major defense companies for use in their products

Current Solutions for Longer Missions

The two most common options used to increase available power to AN/PRC-148:

- Use a battery eliminator to attach the radio to a large wearable power source such as xx-2590.
- Use Soldier Power Adapter Interface (SPAI) to allow direct power to the radio while charging the battery

Battery Eliminator

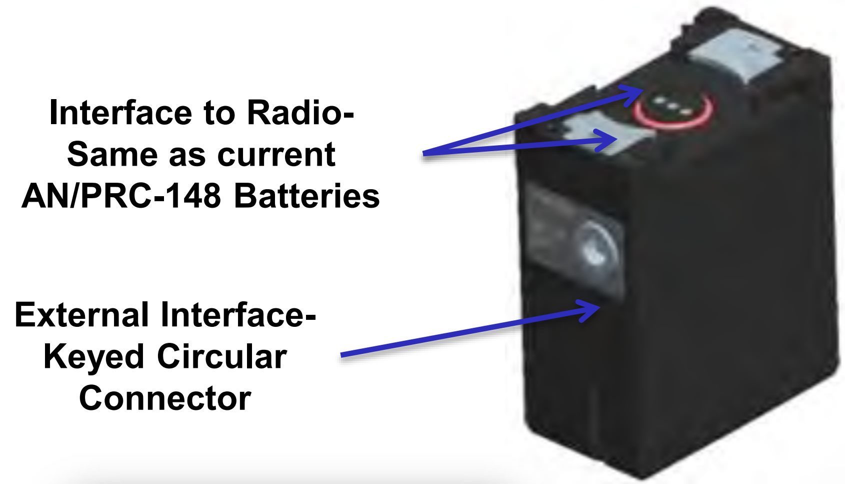
Soldier Power Adapter Interface

Current Solutions- Tradeoff

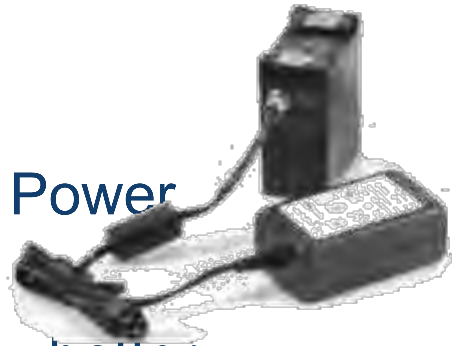
Feature	Battery Eliminator	SPAI
Supply power	No. Does not have internal power source	No. Does not have internal power source
Accept power from DC sources	Yes	Yes
Maintain Communication link when replenishing power source	No	Yes
Maintain Communication link when disconnected from external power source	No	Yes
Fits in the holster	Yes	No. Adds significant height and weight
Reduces Weight	No. Requires a battery eliminator in addition to the standard battery carried by the user	No
Provides Smart Interface for Charging when connected to secondary sources	No	No

Light Weight Smart Battery (LWSB)

- LWSB battery is also referred to as Universal Battery
- LWSB is a new rechargeable battery compatible with AN/PRC-148 with reduced weight, capable of harvesting power from or supplying power to stationary and wearable power sources
- It maintains the same physical and electrical interfaces as current AN/PRC-148 batteries



Universal Battery (LWSB)- Key Features



- ✓ Internal battery using 18650 lithium ion cells
- ✓ Provides a bi-direction (input/output) side port- Power sourcing and harvesting applications
- ✓ Smart SMBus interface to allow smart charging- battery controls charging rate and status
- ✓ Intelligent charger on board which allows either side or bottom charging
- ✓ Its architecture allows for future expandability to incorporate inductive charging, . .
- ✓ Greater than 30% reduction in weight compared to standard AN/PRC-148 battery
- ✓ Provides a user indicator status
- ✓ Flush mount side charging

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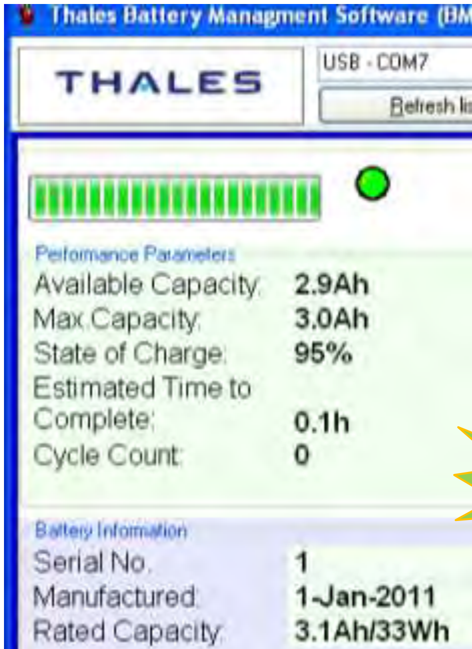
Compatibility with Fielded Ancillary Products

Interoperates with fielded ancillary equipment



Thales 6-bay Combo charger 1600700-3

LWSB

PRC-148 Battery

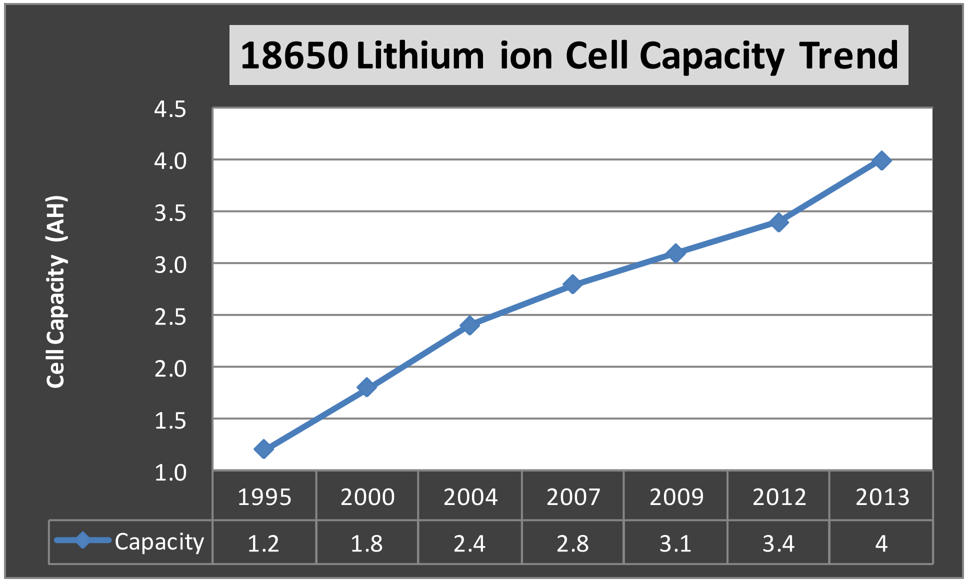
PRC-154 Battery

Liberty

THALES

Impact of Lithium Ion Cell Capacity Upward Trend

- The 18650 cell capacity has improved dramatically during the last 10 years
- The current standard AN/PRC-148 high capacity battery is 60% higher in capacity today than in 2004.
- The 18650 cell capacity is anticipated to increase in the coming years.
- 3.4 AH 18650 cells are expected to be in production by 2012 and 4.0AH cells by 2013
- This upward trend will provide about 43 WH of energy in LWSB in 2013



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- LWSB power can harvest power from various available wearable and fixed power sources
  - Zinc Air
  - Fuel Cell
  - Wearable Batteries
  - Vehicle Power
  - Solar

- LWSB design architecture allows future growth for wireless energy harvesting

THALES

LWSB Power Harvesting- Zinc Air

- LWSB voltage range supports direct connection to Zinc-air batteries to support extended life missions
- In this scenario, the user can charge the battery while operating the radio when LWSB is connected to 8140 or similar Zinc-air batteries.

Zinc-air
BA-8140S

THALES

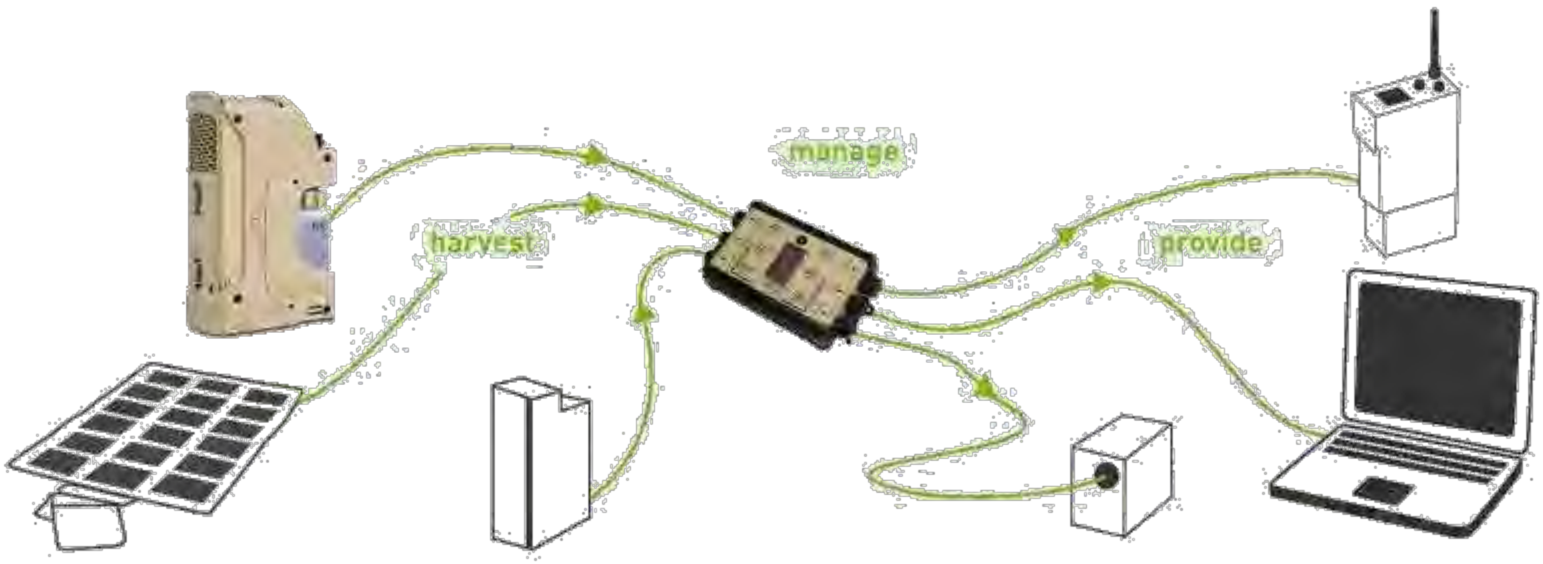
LWSB Power Harvesting- Zinc Air

- Over 1,000,000 zinc-air cells shipped in the last 8 years of production
- 13.6 volt Nominal Voltage
- 30 Amp Hour/400 Watt Hours
- Weighs about 3 pounds
- Designed to slide into the Plate Pouch in Body Armor on the outside surface of the SAPI Plate
- Utilizes the Standard Gen 3 Zinc Air cell used in the BA- 8180

Zinc-air
BA-8140C

LWSB Power Harvesting- Fuel Cell

- LWSB voltage range supports direct connection to fuel systems to support field charging applications
- In this scenario, the user can charge the battery while operating the radio when LWSB is connected to Jenney fuel cell or similar



LWSB

THALES

LWSB Power Harvesting- Fuel Cell

- Similarly, the LWSB can directly connect to most available fuel cell solutions to support field charging applications
- In this scenario, the user can charge the battery while operating the radio when LWSB is connected to a portable fuel cell.
- The picture here shows is direct operation using SFC Jenney fuel cell.

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LWSB- Power Sourcing Applications

- LWSB allows both sourcing and charging power through its secondary port
- For instance, LWSB can be used to provide power to a DAGR (Defense Advanced GPS Receiver) to substantially improve DAGR runtime across temperature
- LWSB can supply power while being charged simultaneously for specific applications

Table 2-1. Key Characteristics and Advantages of DAGR Solution

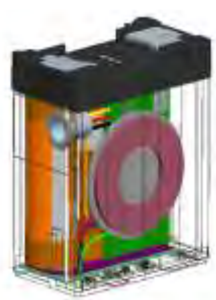
Item	Current Solution: Primary Battery Magazine	External Rechargeable Battery using LWSB
Power Source	Attached to DAGR	External
Battery Technology	Alkaline	Lithium ion
Cell Type	AA	18650
Runtime @ 25 C	~16 hours	~63 hours
% increase runtime	---	360%
Runtime @ -20 C	~2 hours	~50 hours
Wireless charging	NA	Yes
Low Temperature Spec	-18 C	-30 C

THALES

The LWSB design allows addition of wireless technologies for charging.

The two areas of focus at Thales are 1) inductive charging and 2) RF energy Harvesting

1. Inductive charging
   - Incorporate inductive charging to allow <8 hour charging
2. RF Energy Harvesting
   - currently evaluating RF energy harvesting for long term storage applications and residual charging during actual radio use



Inductive Charger

- Initial prototype testing at AFSOC in Ft Walton Beach FL was successful. Demonstrated direct charging from Fuel cell, and XX-2590 with BRITES, and SFC power management interfaces.
- Also demonstrated interoperability with AN/PRC-148 and AN/PRC-152 radio.

Test and Evaluation- AFSOC 2010

LWSB connected to AN/PRC-152, Protonix Power management unit and Ultracell Fuel Cell

LWSB connected to AN/PRC-148, SFC Power management unit and XX-2590 battery

THALES

Large Format Lithium Power Cells for Demanding Hybrid Applications

Adam J. Hunt
Manager of Government Programs

2011 Joint Service Power Expo

Power to Sustain Warfighter Dominance

Myrtle Beach, SC

May 4, 2011

ENER1

CONTENTS

GLOBAL SUPPLY STRATEGY

Total Employees: 750 （Excl. China/Think)
Symbol/NASDAQ: HEV

U.S. FACILITIES

Easily replicated production processes allow us to expand capacity and locate facilities in-country near clients' facilities

- Ener1 Lithium Group Established in 1990
- Delphi Lithium Group 1998
- EnerDel 2004
- Total Area: ~ 98,000 ft^2
- Production & R&D of Lithium-Ion Cells for multiple applications

- Lease signed January 2010
- Total Area: 400,000 ft^2
- Production Lithium-Ion Cells for multiple applications
- Final Pack Assembly Operations
- Production Launch in May
- Made possible by $118.5 million in federal grant funding under the ARRA stimulus package

- Established in 2009
- Floor Space -38,500 ft^2
- BMS Engineering & Test

TOTAL SOLUTION PROVIDER FOR LI-ION BATTERY SYSTEM

EnerDel battery system concept provides maximum flexibility to meet customer's requirement

CELL

- Advanced Prismatic Design
- High Performance Li-Ion Cells

MODULE

- Easy Maintenance Module Concept
- Integrated Thermal Management
- Voltage & Temperature Monitoring

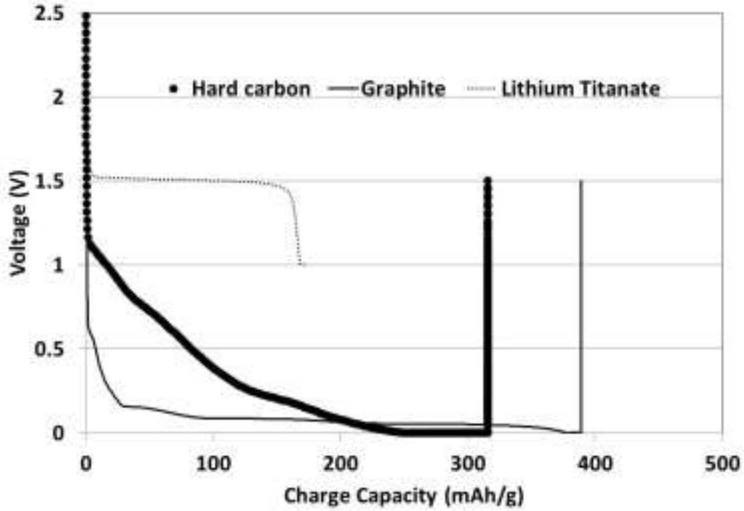
SYSTEM

- High Speed Vehicle Communication
- Robust Battery System
- Integrated reuse design concept

EV System | **HEV System**

NEGATIVE ACTIVE MATERIAL COMPARISON

- Graphite
  - Most common active material for existing lithium ion cells
  - Most energy density per volume
- Non-graphite carbon
  - Less reaction with electrolyte than graphite
  - Higher power than graphite
  - Longer life than graphite
- Lithium Titanate (Li4Ti5O12)
  - No reaction with electrolyte
  - Less impedance
  - Longer life
  - Less Energy density



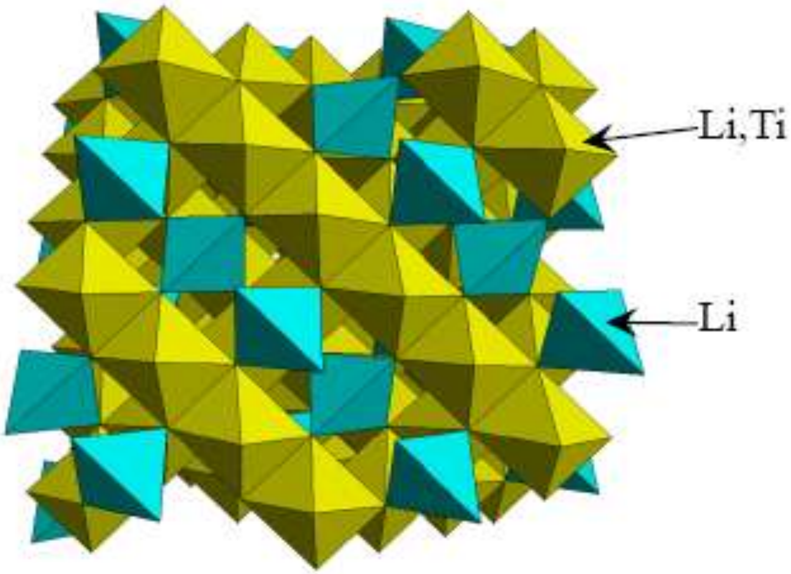
NEGATIVE ACTIVE MATERIAL COMPARISON

Characteristic	Graphite	Carbon	Lithium Titanate
Long Life	3	2	1
Power	3	2	1
Energy	1	2	3
Low temperature	3	2	1
Safety	3	2	1

1 – BEST 2 – BETTER 3 - GOOD

Lithium Titanate cell performance will be presented in this presentation

The Titanate Anode



- A very stable oxide best known for its safety and long cycle life
- Theoretical capacity of 165 mAh/g is about half that of graphite (372 mAh/g)
- It operates at 1.5V vs. Li which is above the voltage at which Li dendrites can occur
- Less than 0.2% volumetric change from fully discharged $Li_4Ti_5O_{12}$ to fully charged $Li_7Ti_5O_{12}$ titanate (for comparison, graphite is 9% and silicon is 300%)

<J. Electrochem. Soc. 146(1999) 857>

LTO CHARACTERISTICS

- Advantages
  - Zero strain material
    - LTO ~ 0.02 % volume change
    - Graphite ~ 9% volume change
  - No lithium dendrites
  - Less impedance than graphite

↓

✓High power
✓Good low temperature performance
✓Long life
✓Safety

- Disadvantages
  - Lower Energy Density
  - Lower Voltage

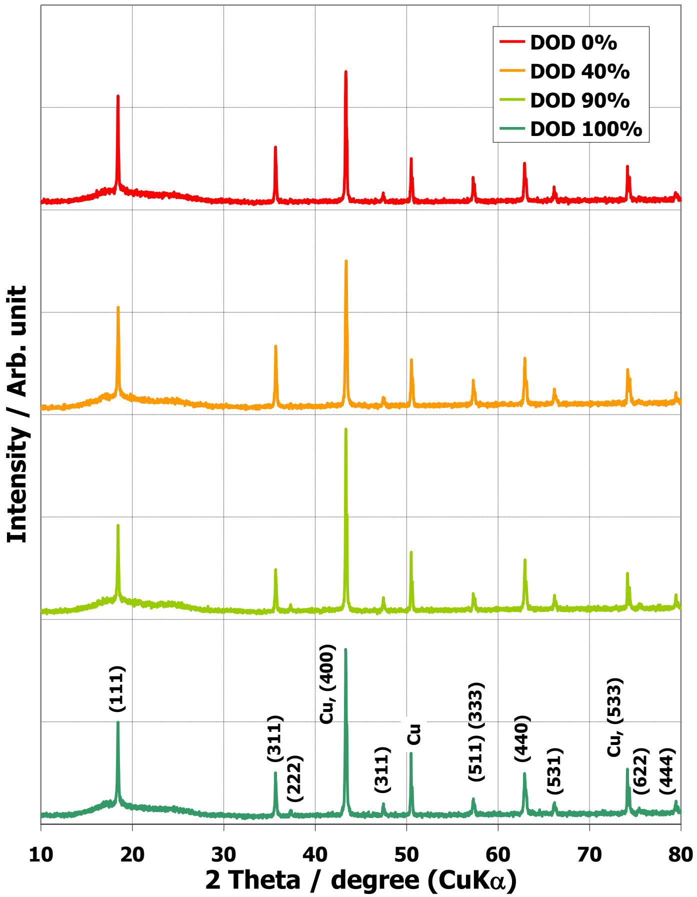
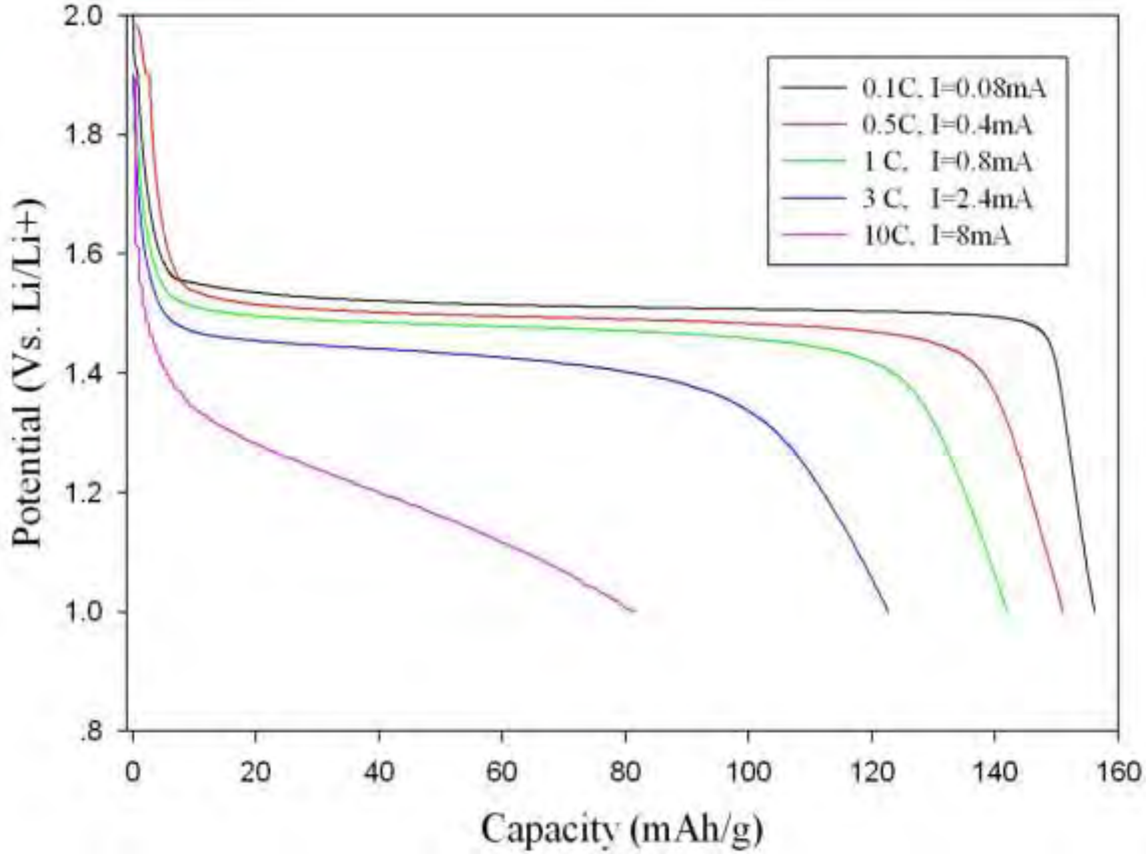


Fig. XRD patterns of LTO material at different DOD

$Li_4Ti_5O_{12}$ - spinel (LTO)

$$Li_4Ti_5O_{12} + xLi^+ + xe^- \leftrightarrow Li_{4+x}Ti_5O_{12}$$

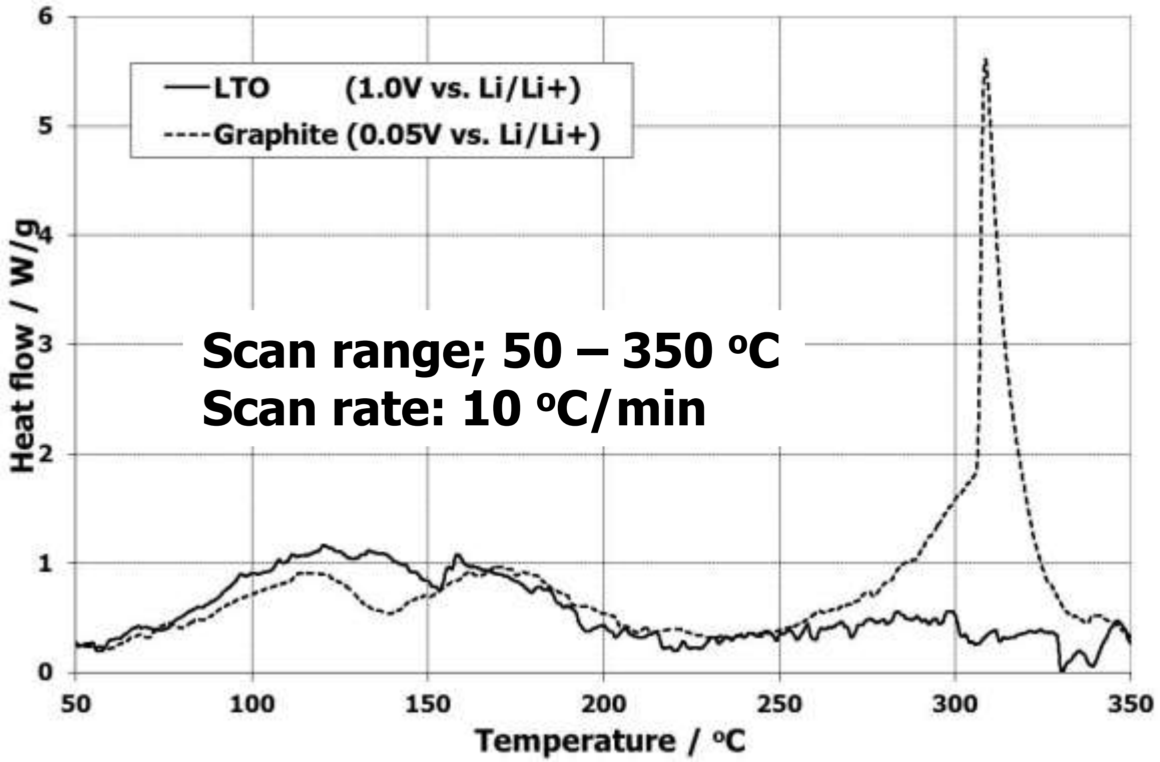
LTO Anode



- The Li insertion in titanate occurs at ~1.5V, well above the voltage at which Li deposition occurs

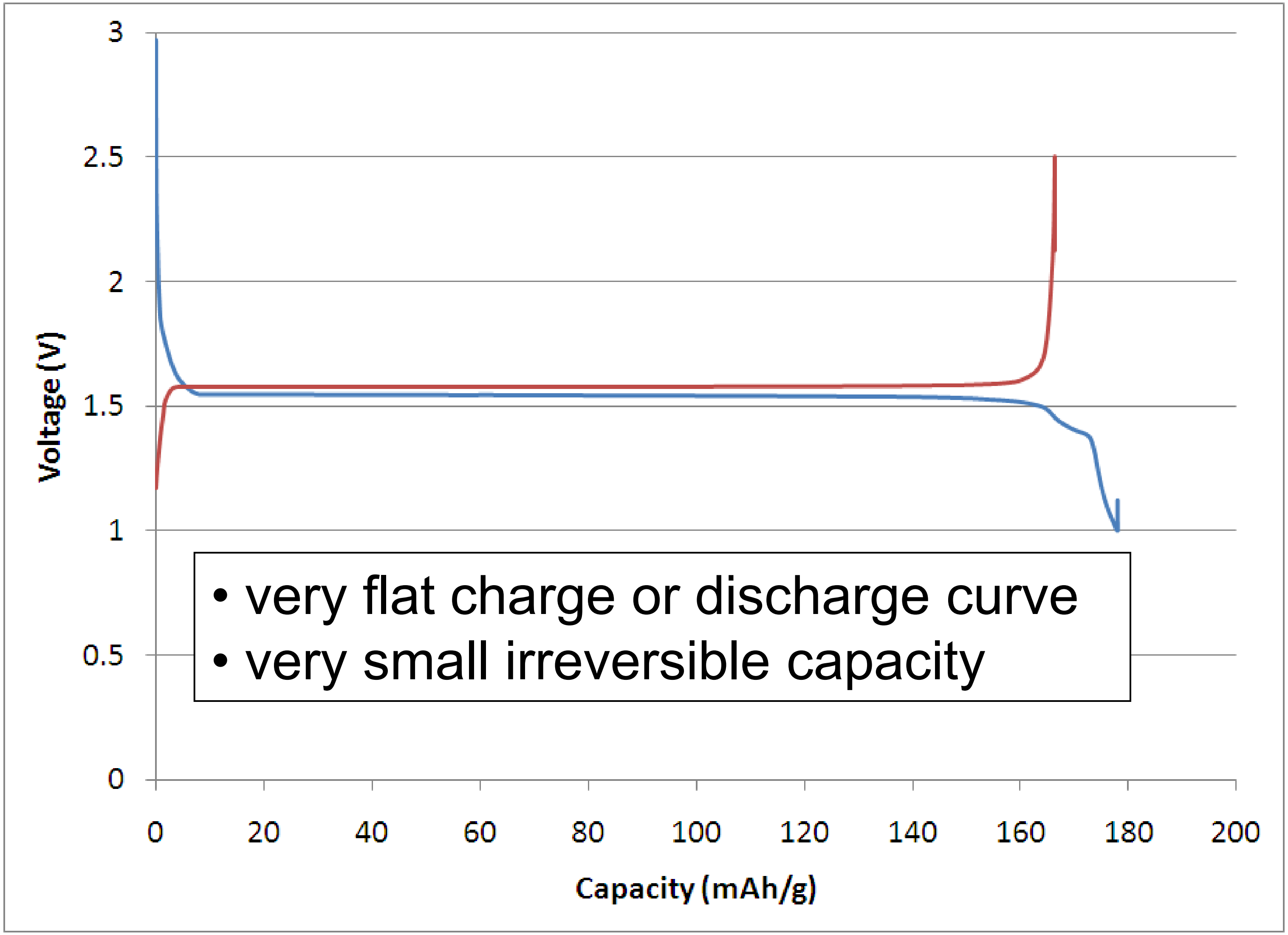
Stan Whittingham SUNY

THERMAL STABILITY OF LTO



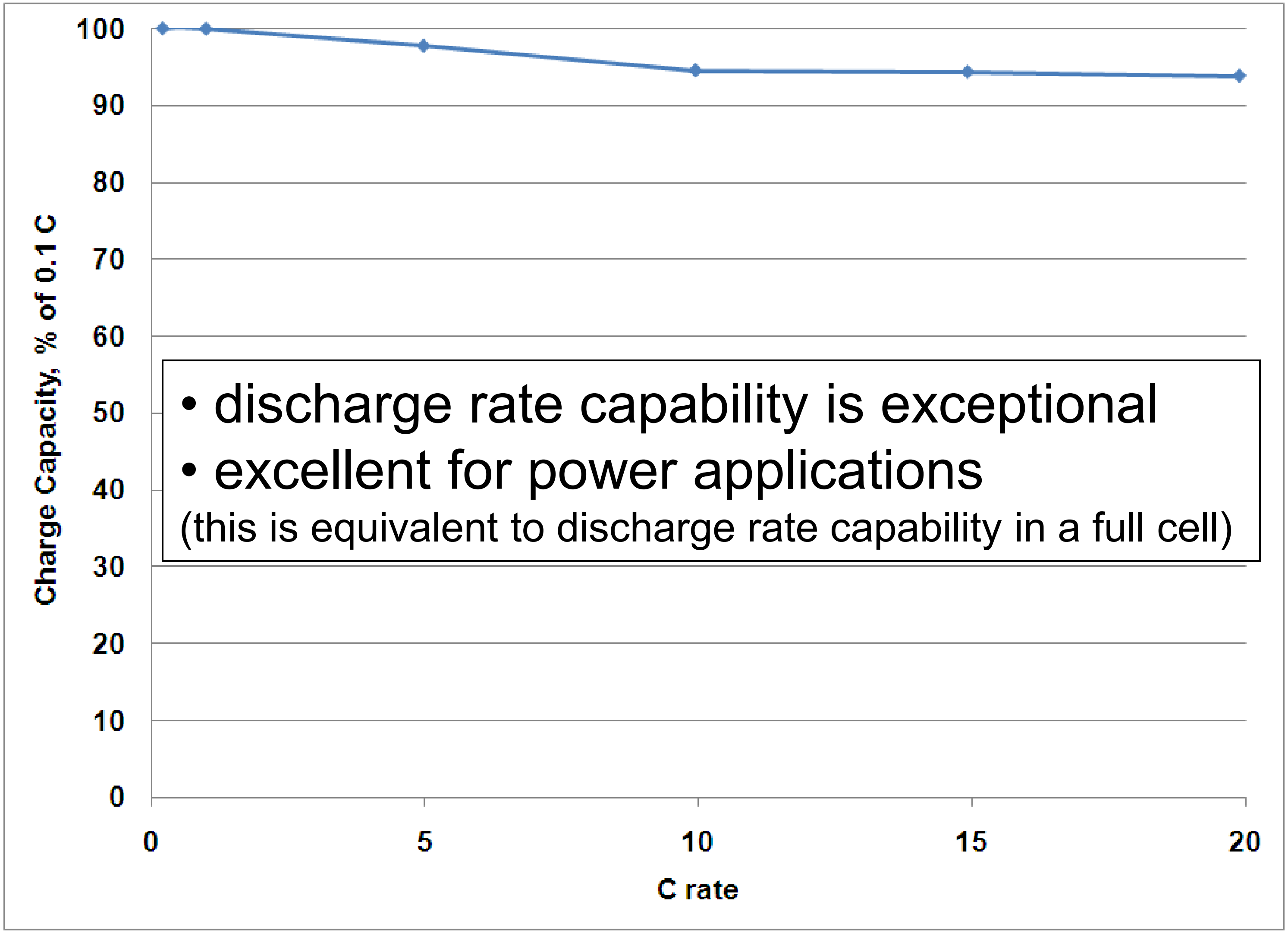
LTO negative shows less heat generation than graphite negative

LTO HALF CELL RESULTS



ENER1

LTO HALF CELL RESULTS



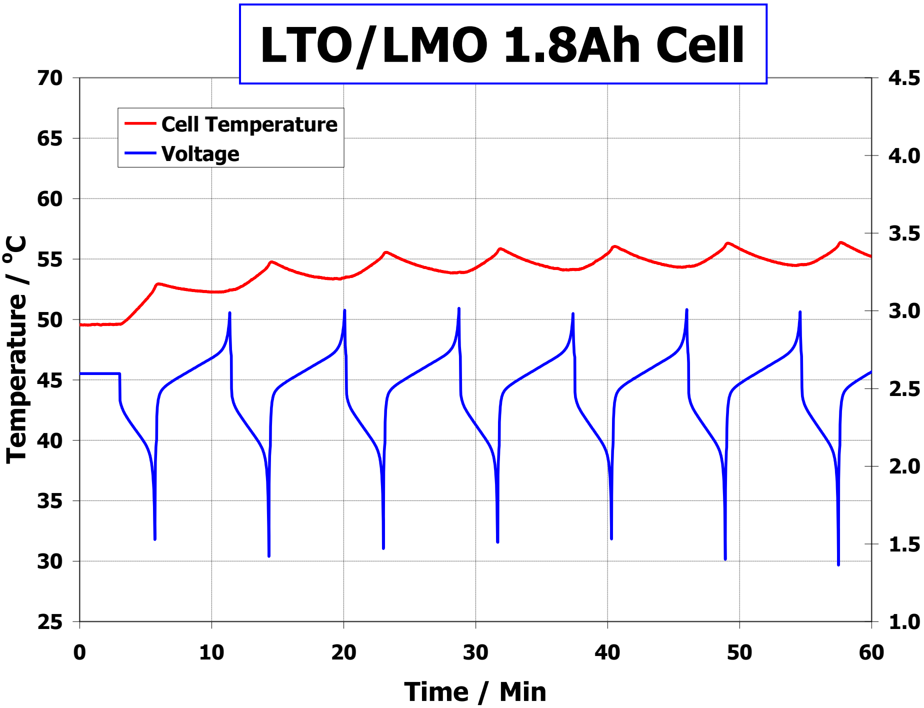
- discharge rate capability is exceptional
- excellent for power applications

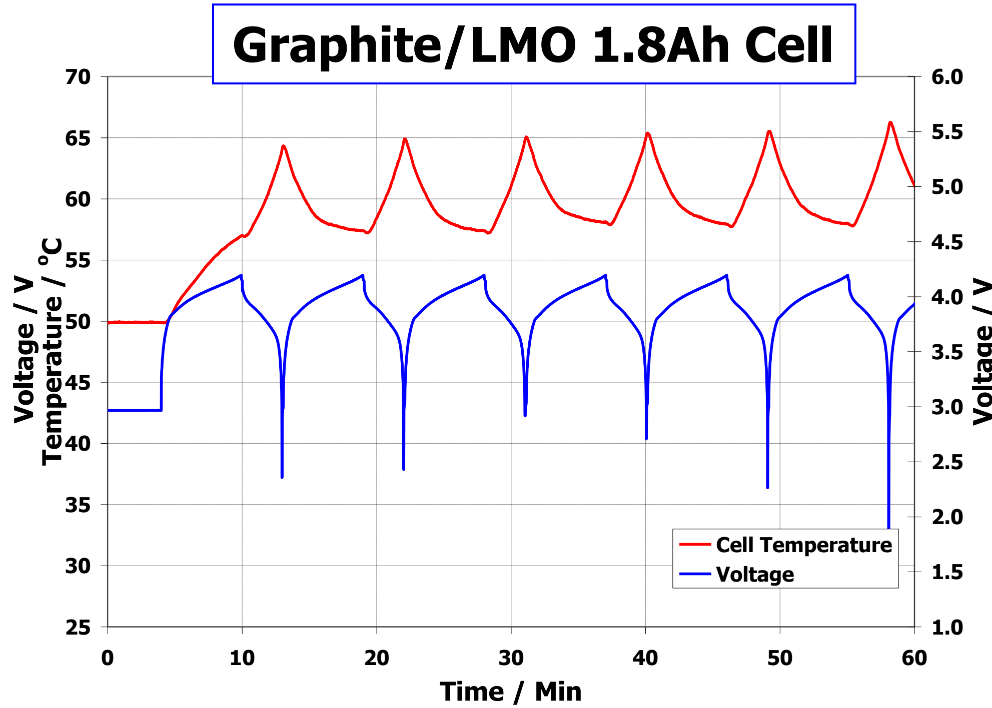
(this is equivalent to discharge rate capability in a full cell)

ENERDEL SMALL CELL DESIGN FOR LIGHT-DUTY VEHICLE APPLICATIONS

DESCRIPTION	SPECIFICATION	
Application	Light-duty vehicle	
Nominal Capacity	1.8Ah	5Ah
Max Voltage	2.8V	
Min voltage	1.5V	
Cell size	145 x 130 x 5 mm	200 x 111 x 5 mm
Chemistry	LTO/LMO	

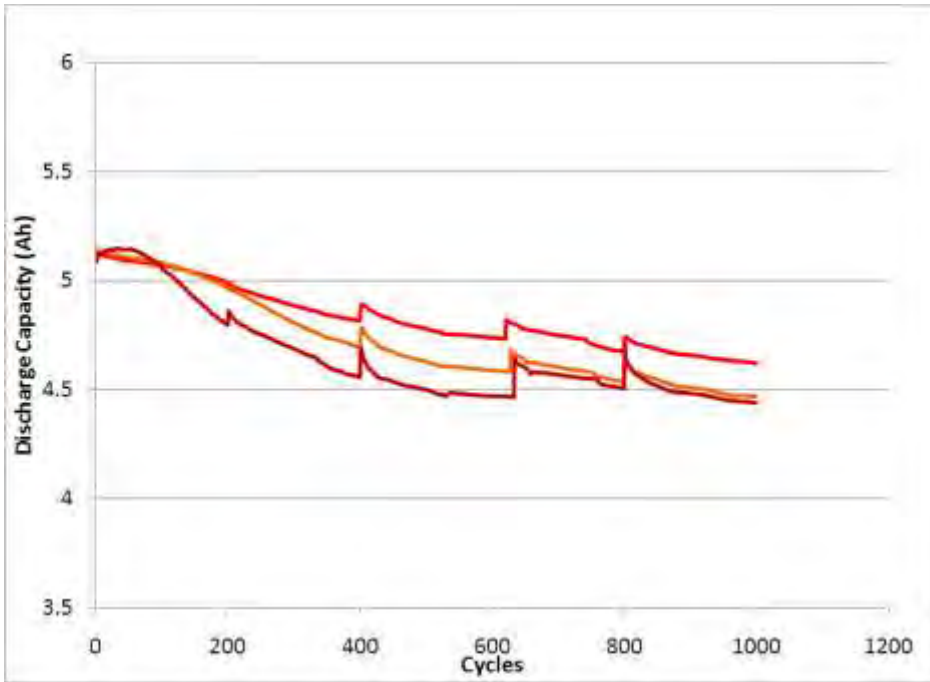
TEMPERATURE INCREASE AT HIGH POWER CYCLE

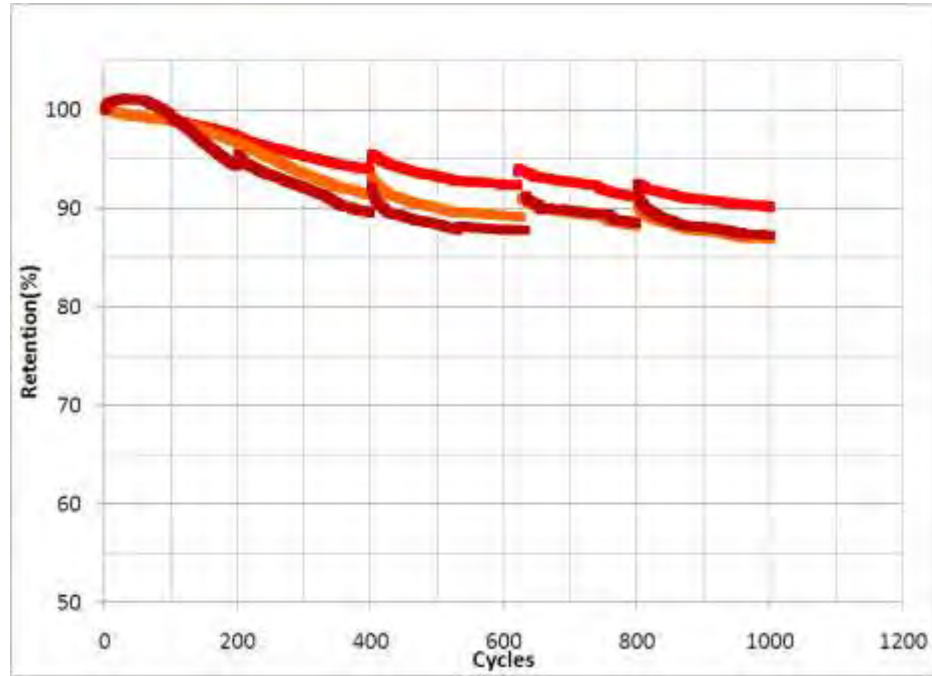




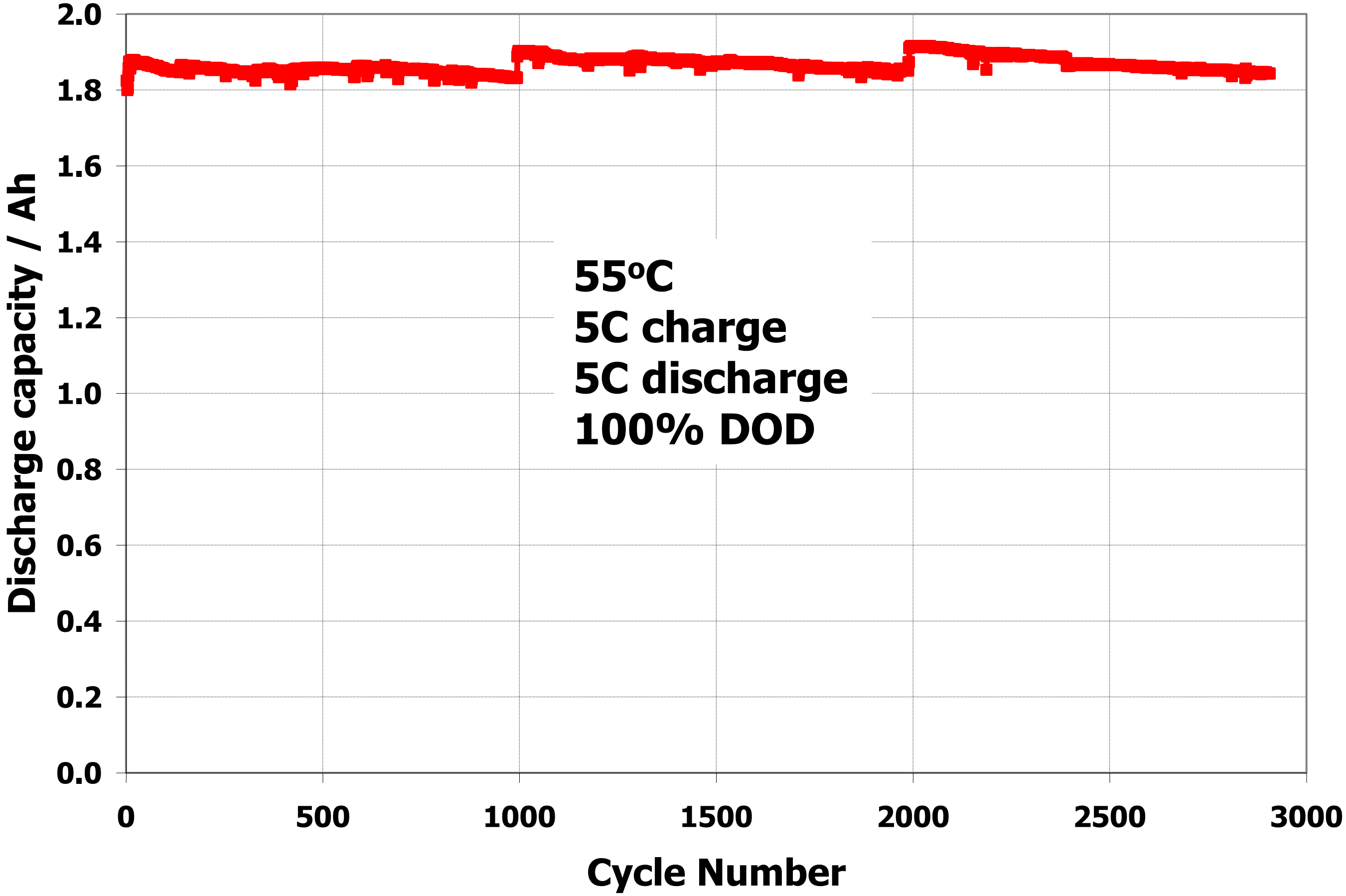
5 AH FULL CELL: HIGH TEMPERATURE CYCLING

- 2C cycling at 55° C
- excellent high temperature capacity retention





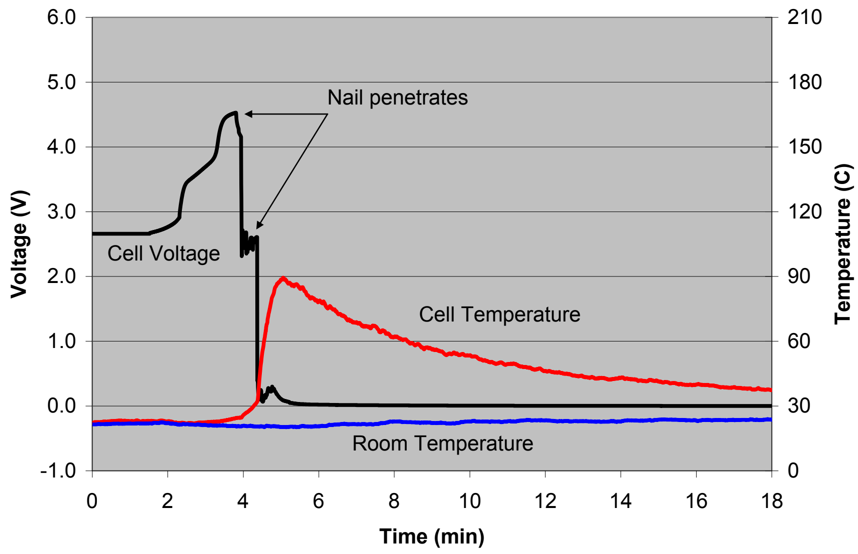
CYCLE LIFE

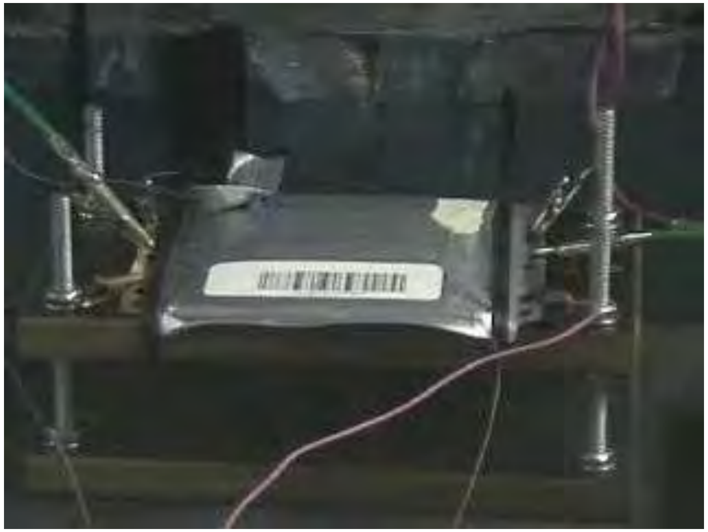


- No capacity loss under severe cycling conditions.

EXTREME ABUSE TEST, LTO CELLS

Overcharge and nail penetration





HEV BATTERY PACK WITH ENERDEL LTO CELLS

We can reduce the battery size by one-half compared to existing Ni-MH pack

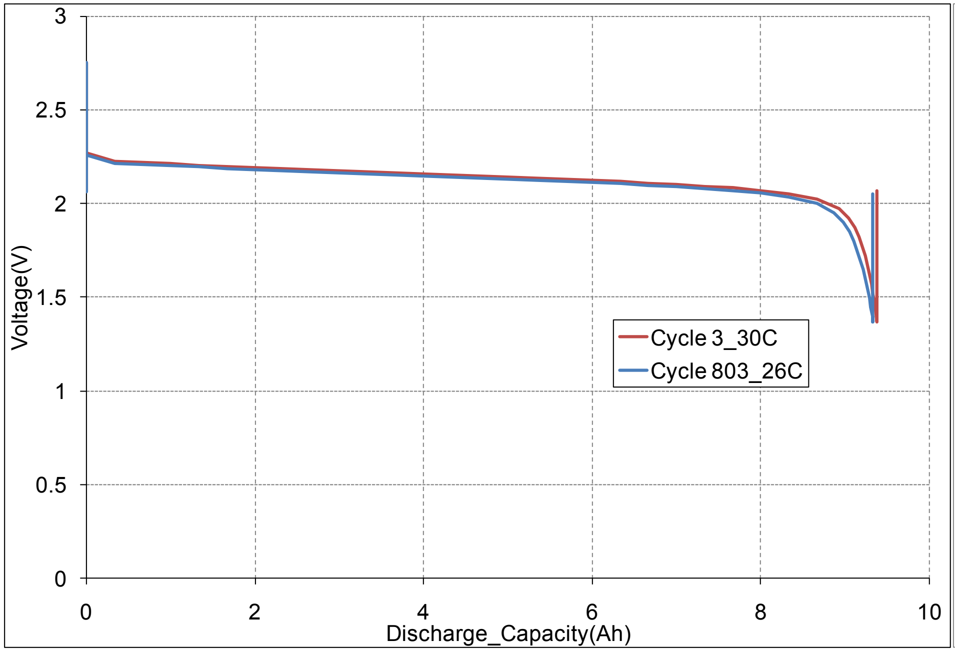
	CHEMISTRY	RATED ENERGY	AVAILABLE ENERGY	MAXIMUM POWER
Current	Ni-MH	1.2kWh	0.3 kWh	40kW
EnerDel	LTO	1.0kWh	0.8 kWh	80kW

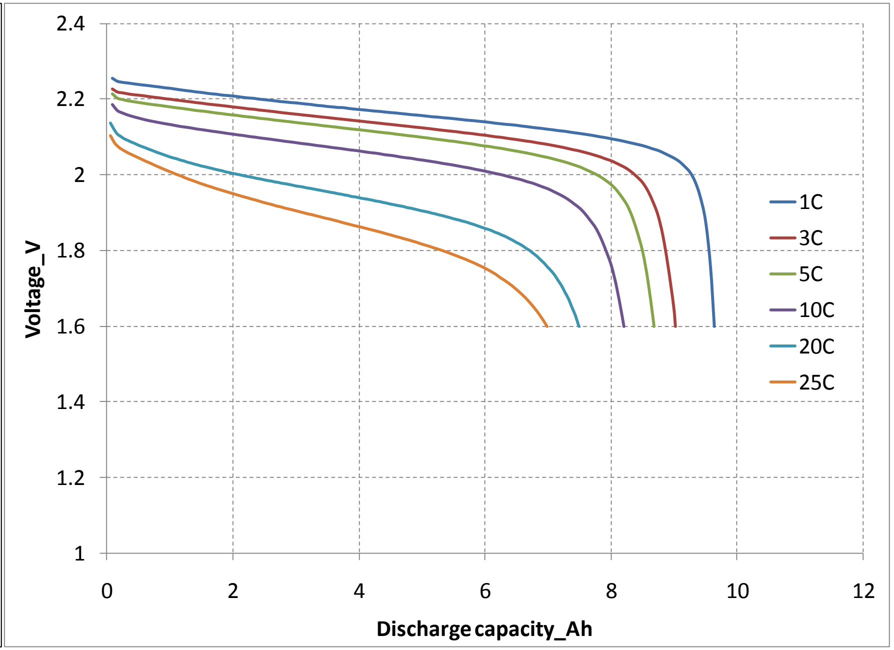
LARGER SIZE LTO CELL

DESCRIPTION	SPECIFICATION
Application	Heavy-duty vehicle
Nominal Capacity	9.5Ah
Max Voltage	2.75V
Min voltage	1.6V
Cell size	172x 253 x 5.8 mm
Chemistry	LTO/Mixed Oxide

- Mixed oxide was used for the positive active materials instead of LMO

DISCHARGE PROFILE– 9.5AH CELL

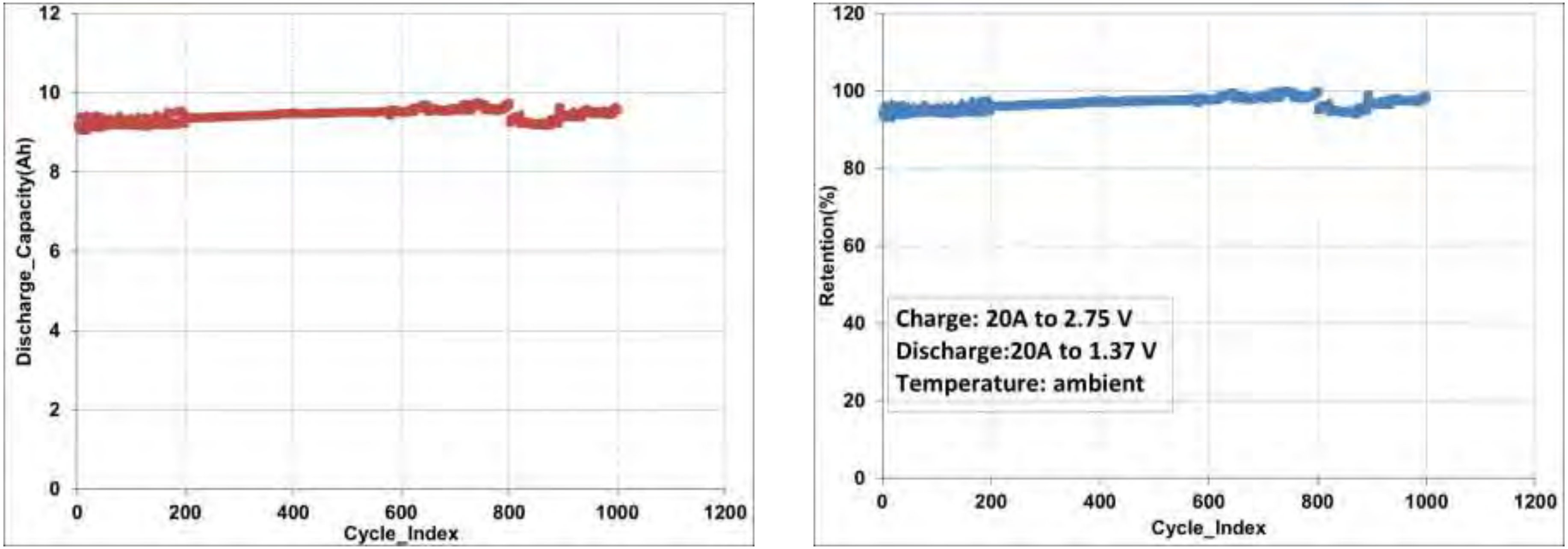




Discharge profile comparison at 3rd cycle and 803rd cycle

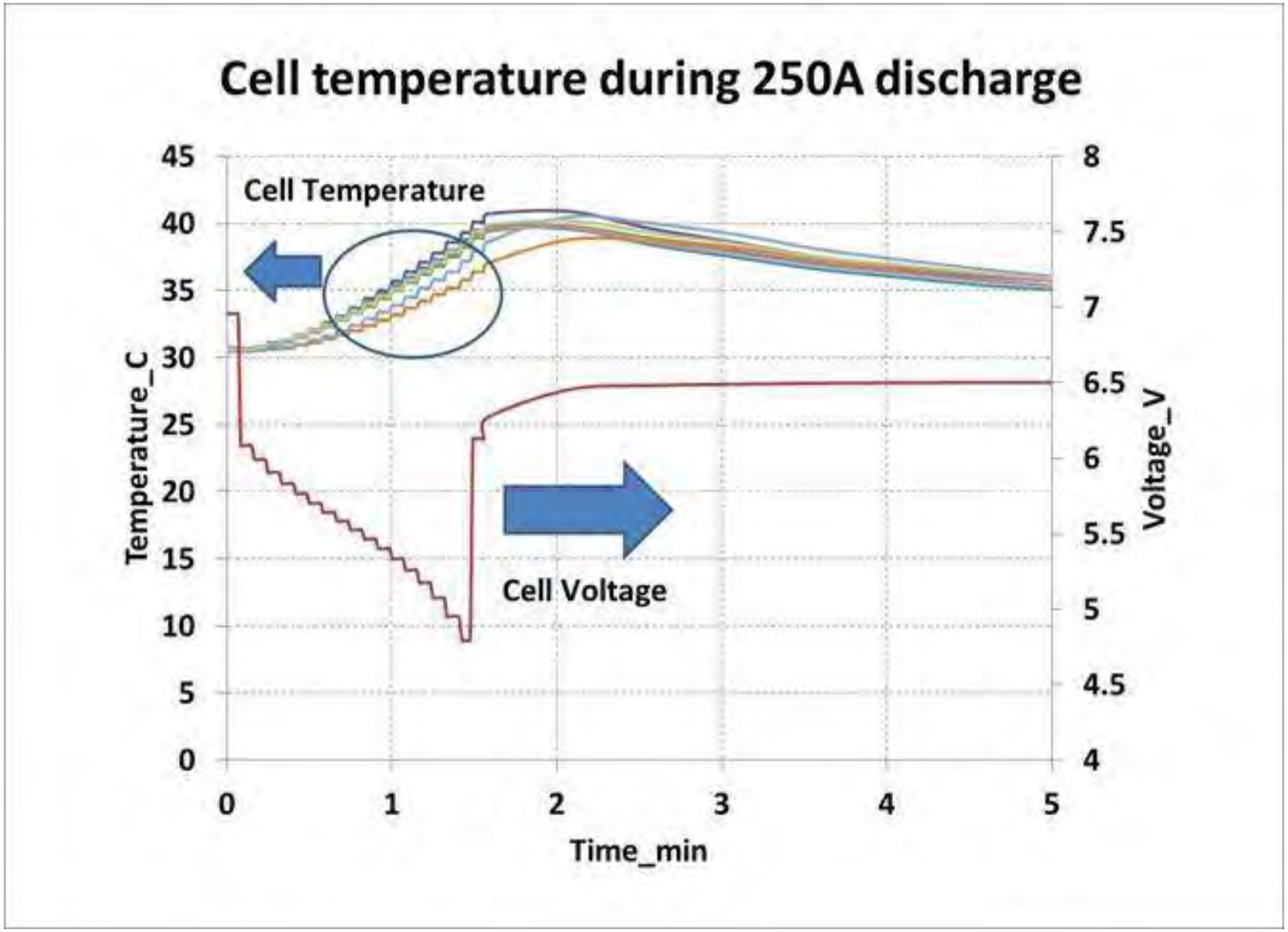
Rate Capability

CYCLE LIFE – 9.5AH CELL



Capacity loss is not observed through first 1000 cycles.

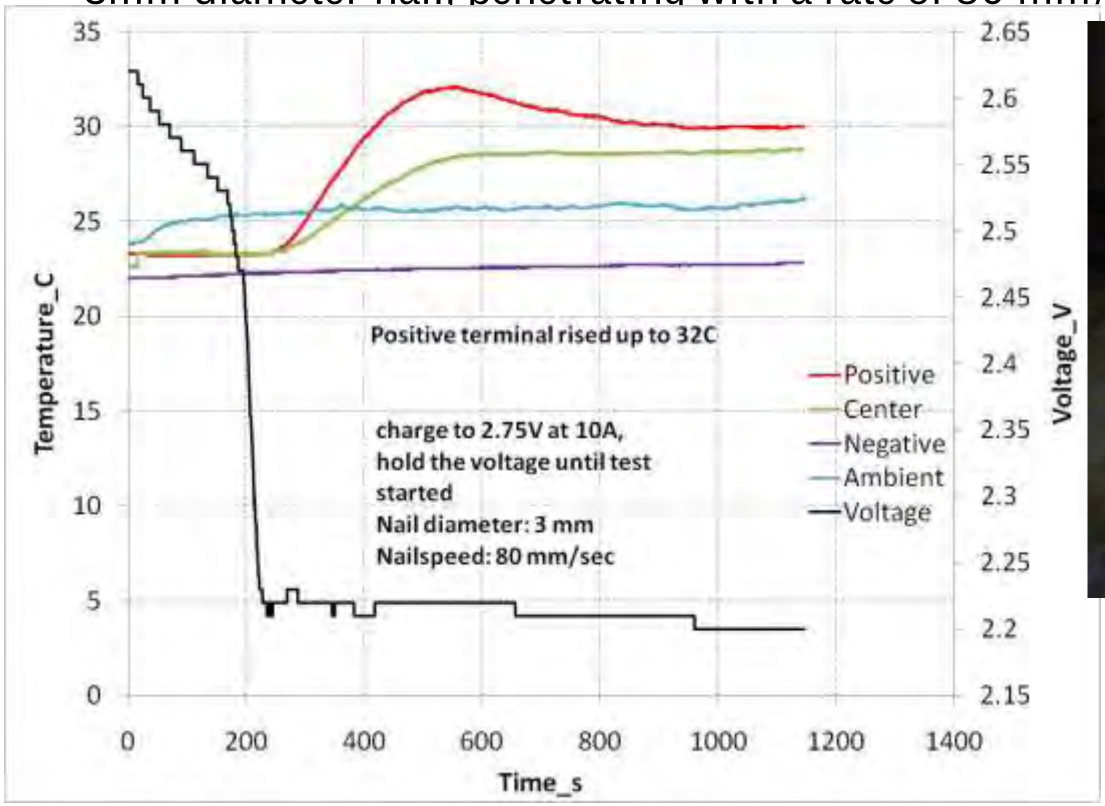
THERMAL TEST WITH 3 CELLS IN SERIES (30° C)



8 points of the cell temperature were measured
Max 10°C increase with 25C continuous discharge

NAIL PENETRATION (9.5AH CELL)

3mm diameter nail, penetrating with a rate of 80 mm/s



- No thermal event was observed. No explosion, no fire, no flame, no smoke. Irreversible cell damage.
- EUCAR /SAE J2464 hazard level = 2
- Cell was not shorted right away. It took 1 hr for the cell voltage to reach 0V
- Positive terminal temperature reached 32° C

CONCLUSIONS

- SAFE
- LARGE FORMAT
- HIGH POWER
- LONG LIFE
- MECHANICALLY STABLE
- MADE IN THE UNITED STATES
- COMPATIBLE WITH EXISTING ENER1 MODULE STRUCTURE

ACKNOWLEDGEMENT

Ener1 would like to thank the Department of Energy – National Energy Technology Laboratory for funding under cooperative research agreement DE-FC26-08NT01929 and the U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) for Financial Support in the continued refinement and demonstration of the Titanate High-Power cells used for W56HZ-09-C-0681.

THANKS FOR YOUR ATTENTION!

PLEASE VISIT US IN BOOTH #110

ADAM J. HUNT – MANAGER OF GOVERNMENT PROGRAMS

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WWW.ENER1.COM

U. S. Marine Corps Expeditionary Power Systems

Marine Corps Renewable Energy and Microgrid Efforts

Clint Justin Govar

Joint Service Power Expo
Myrtle Beach, SC

May 1-5, 2011

- What Drives Marine Corps Power Acquisition?

- MCSC Micro Gird/hybrid generator efforts

- Expeditionary Solar 101

- MCSC renewable energy efforts

Marine Air-Ground Task Forces

Special Purpose MAGTF
~ As required
(Inf Co ~ 72 hrs Sustainment)

Marine Expeditionary Unit (MEU)
~ 1500 – 3K Marines
(15 days of supply)

Marine Expeditionary Brigade (MEB)
~ 3 - 20K Marines
(30 days of supply)

Marine Expeditionary Force (MEF)
~ 20 - 90K Marines

Joint Task Force

Command Element MAGTAF

Ground Combat Element	Aviation Combat Element	Logistics Combat Element
		

Tasked organized, self sustaining, Naval based force

Marine Power & Energy Issues

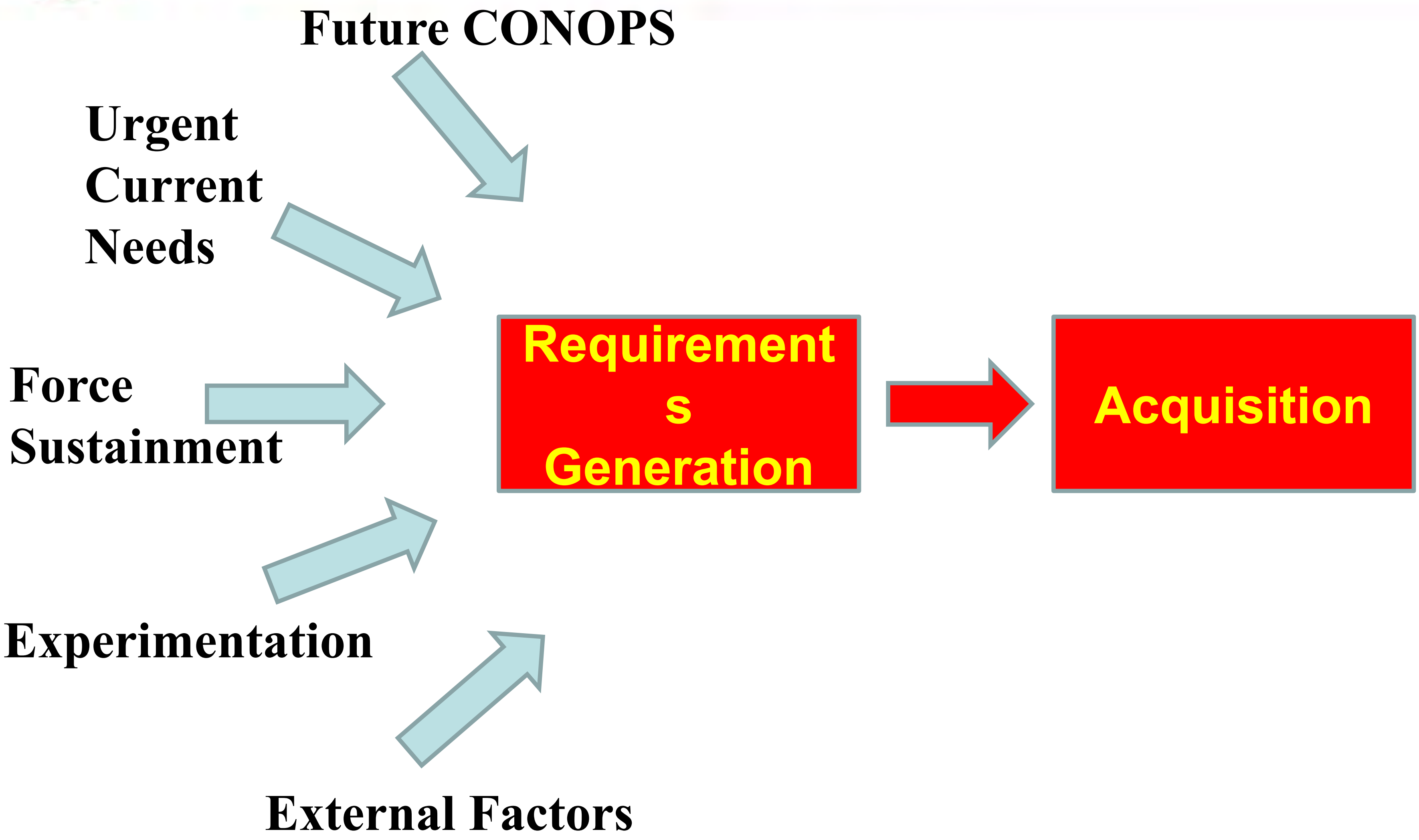
- **Frequently Moved**
- **Wide Energy Tool Box**
- **Space and Weight are at a Premium**
- **Energy Efficiency (Logistic Burden)**
- **Unique Transportation Requirements**
  - Deploying via ship, air or tactical vehicle
  - Surf landing and cross-deck loading
  - EMI from shipboard systems
  - Shipboard stowage / transport (Lithium Batteries)
  - Supply / resupply is from the Naval / Pre-Positioned Forces

KEY TRANSPORTABILITY DRIVERS

Individual Marine (carried):	Assault Load < 75#, Existence < 150#
Lifted by Marines / Loose Cargo:	One person lift – 44 pounds
Requiring Forklift / Material Handling:	> 400 pounds
HMMWV Trailer Towable:	> 2700 pounds
Medium Tactical Truck Carried:	< 7 tons (off road), 10 tons (on road)
Heavy Tactical Truck Carried:	< 16 tons (on road)
MV-22 Tilt-Rotor Lift:	< 4 tons (internal)*, 7.5 tons (external)
CH-53 Helicopter Lift:	< 5 tons (internal)*, 14 tons (external)

* psi limitations apply

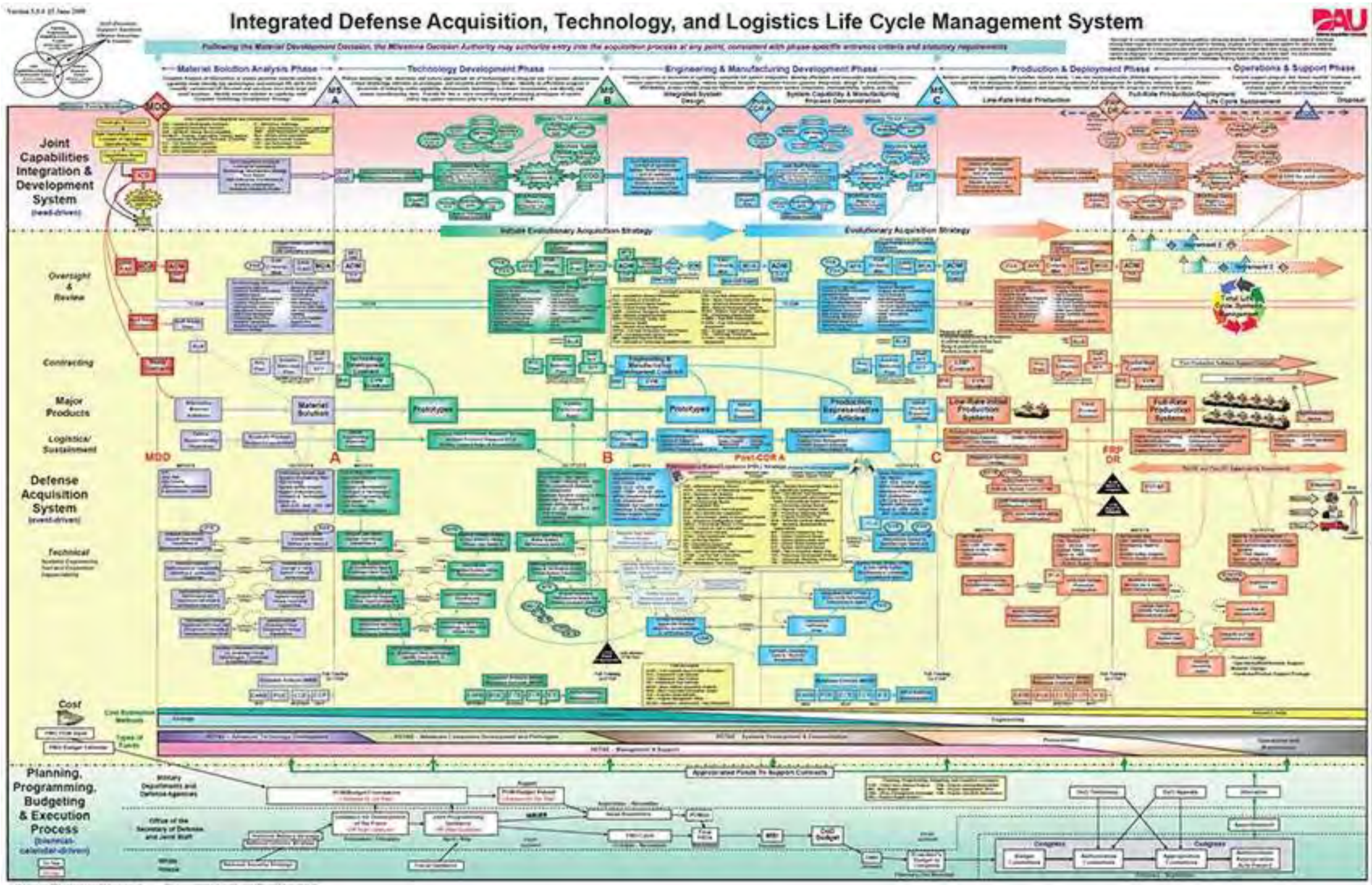
WHAT DRIVES ACQUISITION?



WHY DOES IT SEEM TO TAKE SO LONG?

- User Requirement (Formulation, Resolution, Validation)
- Acquisition Lead Time (process, policy, people)
- Contracting Lead Time (policy, legal, audit)
- Technology Development, Demonstration, Maturation
- Transition from Development to Production
- Suppliers and Parts Long Lead Times
- Development of Logistics Supportability
    - Development of Training Materials
    - Training of Personnel
        - Operations
        - Maintenance
    - Technical Publications
    - Provisioning of Spare Parts and Parts Support

Acquisition Requirements



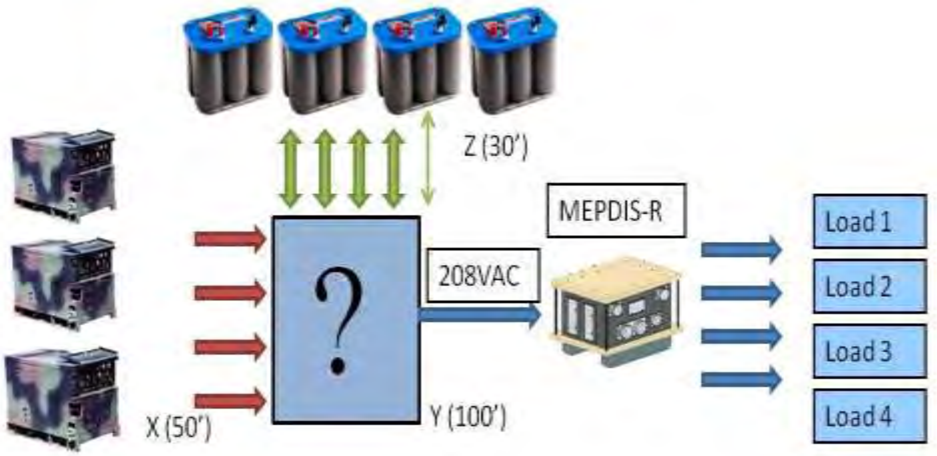
UNCLASSIFIED

- Tactical Integrated Generator Gridding Energy Resource (TIGGER)
  - Initial MCSC MicroGird Acquisition Effort
    - 500kW to 800kW
    - Use of TQGs and MEPDIS-R
    - Load shedding/Grid self protect feature
  - Requirements Flux – TIGGER currently Canceled
- Still Following Army Hi-Power Program
- Still involved Navy and OSD R&D efforts
  - ISUP (10-30kW hybrid Generator)
  - RSUP (3-5kW hybrid renewable energy trailer)

From an Acquisition Point of View the Marine Corps currently has no near term plan to procure a micro grid system

Improved Small Unit Power (ISUP)

- Multi-generator control and hybridization
- Less than 50 kW electric power continuous
- Existing components in military inventory
- Collaborative effort between:
  - OSD (DDR&E)
  - ONR
  - NSWC Carderoc
  - MCSC



- Solar Systems Have 3 to 4 Basic Parts
  - Solar Array
  - Controller
  - Batteries
  - Power Distribution (Often Cables)
  - Auxiliary Power In (Hybrid Generator not in all systems)

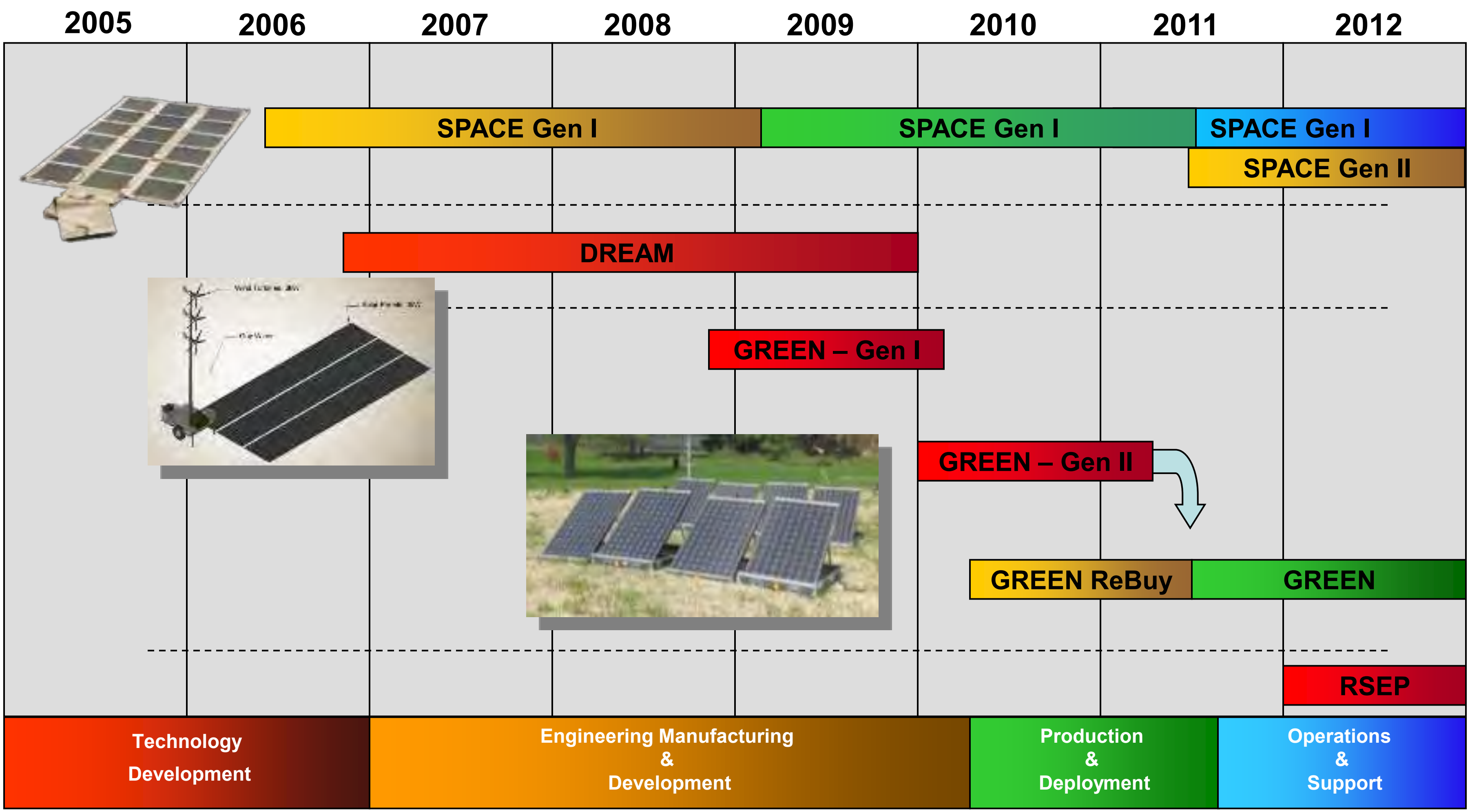
- Larger system do little to decrease total system deployment size and weight
  - Example (two 300W systems vs. one 600W system)
  - Some packaging gains can be achieved

- System weight and size is mostly affected by:
  - Panel Type (brand, flexible vs. rigid) ~ 30% cost
  - Battery type (lead acid vs. lithium) ~ 30% cost
  - Power Management and deployment concept (Packaging strategy and controller i.e. one large box vs. several small boxes) ~ 30% cost

Rating of Solar System

- MCSC rating of solar systems based on solar array size and type
  - "5 rule of thumb" = solar array rating/5 = 24 hour renewable energy rating
  - Still must factor in frequency of bad weather
  - Assumes ideal deployment
- Size of solar array determines % of JP8 reduced
- When rating hybrid systems:
  - Factor in energy storage ability to optimized fuel based generators
- Other important system factors:
  - Peak power capability, output power type, transportability, battery type, survivability, maintainability, etc.

USMC Renewable Energy Efforts

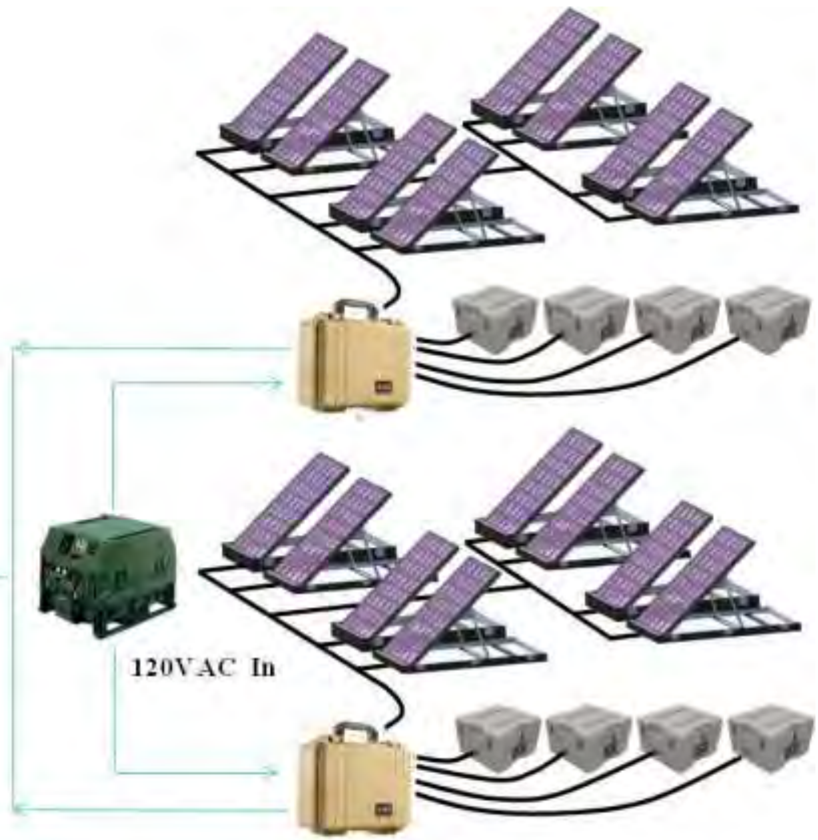


SPACE – Solar Power Adaptor for Communications Equipment (30 Watt continuous)
GREEN – Ground Renewable Expeditionary Energy Network (300 Watt continuous)

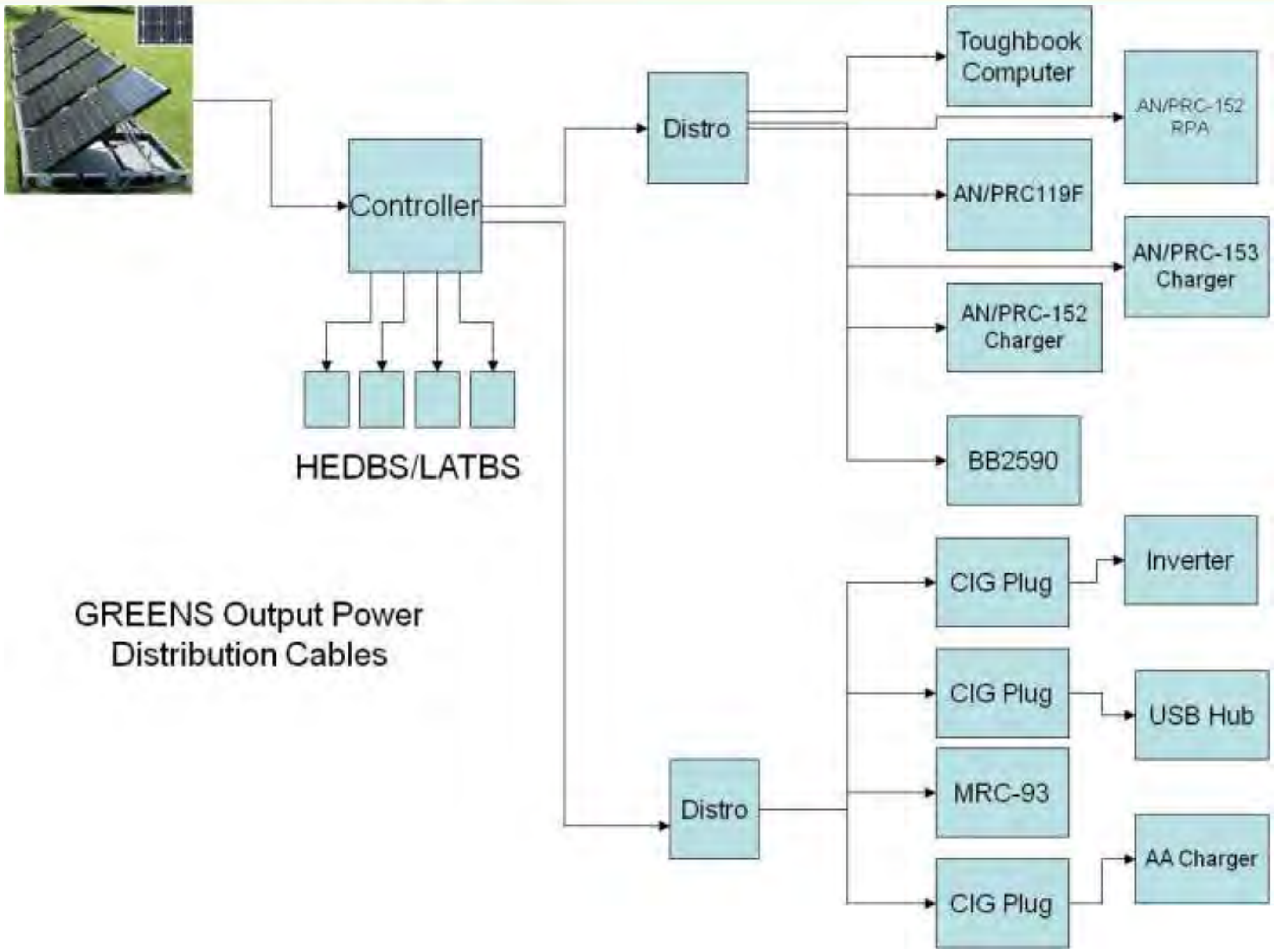
DREAM – Deployable Renewable Alternative Energy Module (1.5 kW continuous)
SREP – Renewable Sustainable Expeditionary Power (3 -5 kW continuous)

Ground Renewable Expeditionary ENergy System (GREENS)

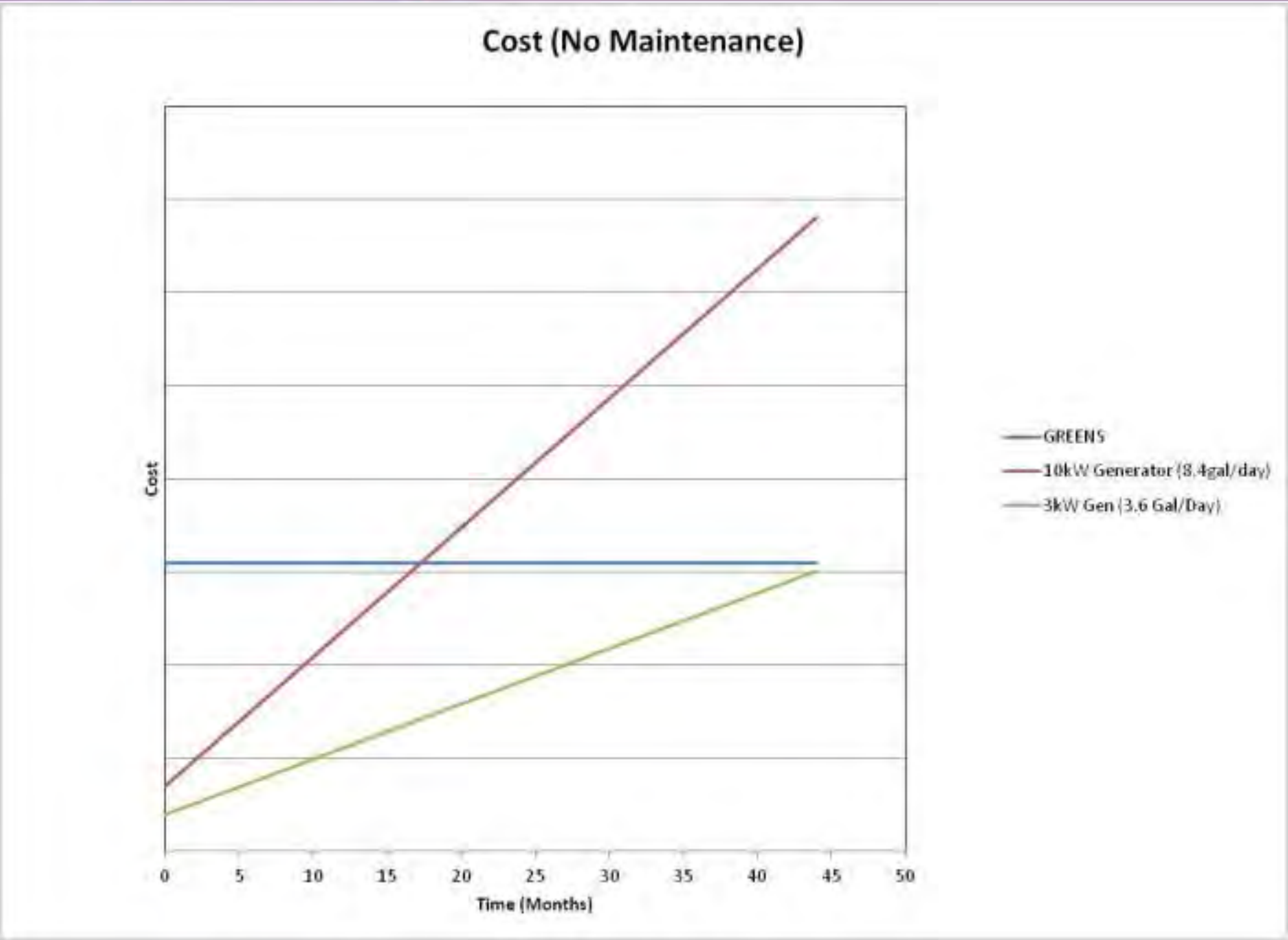
- **300 W continuous power 24/7**
- **Up to 1000 W of output power**
- **24 VDC output power**
- **Multiple possible inputs**
- **Generator auto-start capability**
- **System will include:**
  - **1.6 kW Solar Array of 8 panels**
  - **Controller**
  - **4 - 1.2 kWh battery modules**
- **Man-portable components (< 88 #)**



GREENS Power Distribution

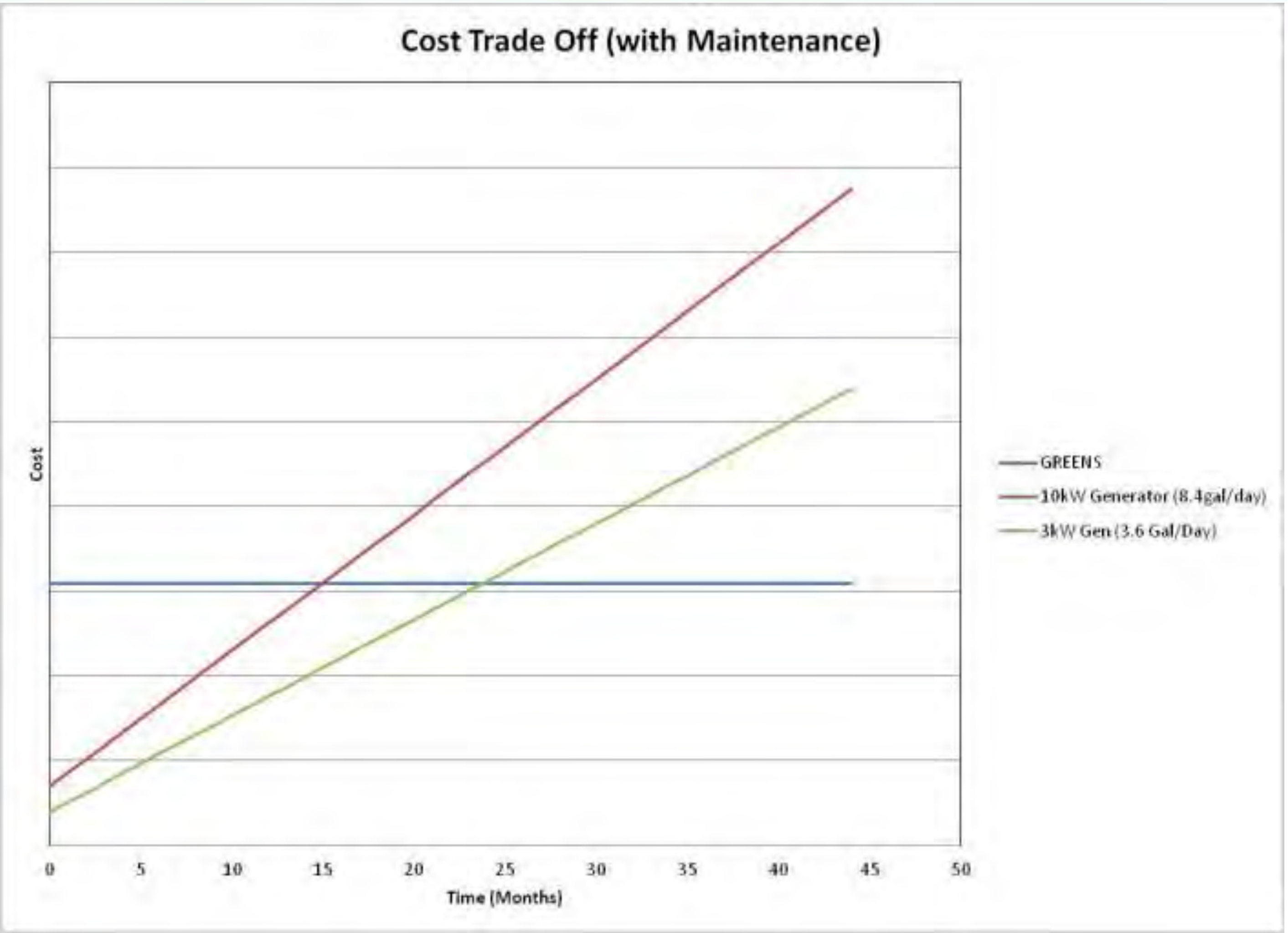


Why GREENS?



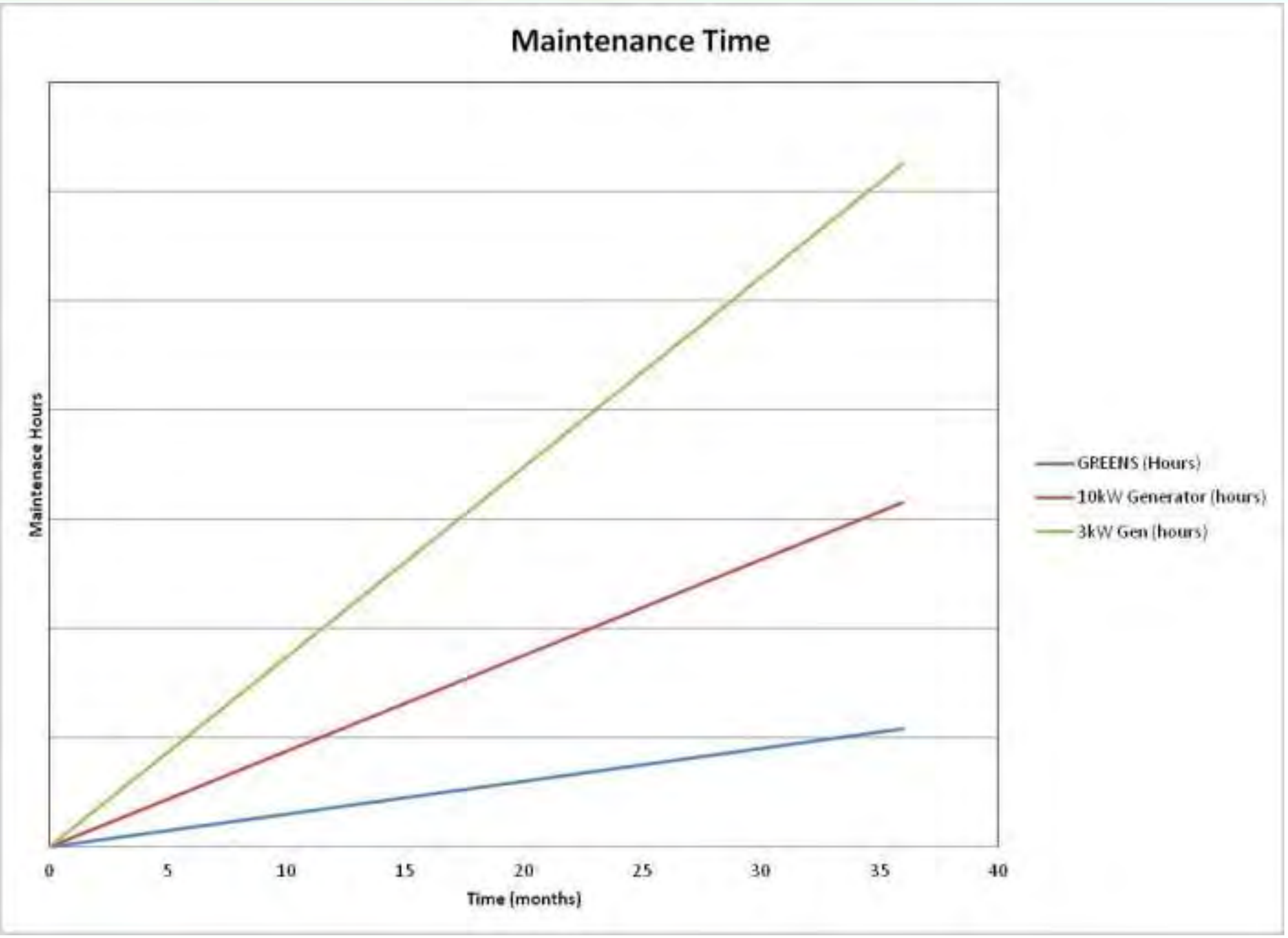
Material cost pay back is ≥ 3.5 years vs. generators

Why GREENS?



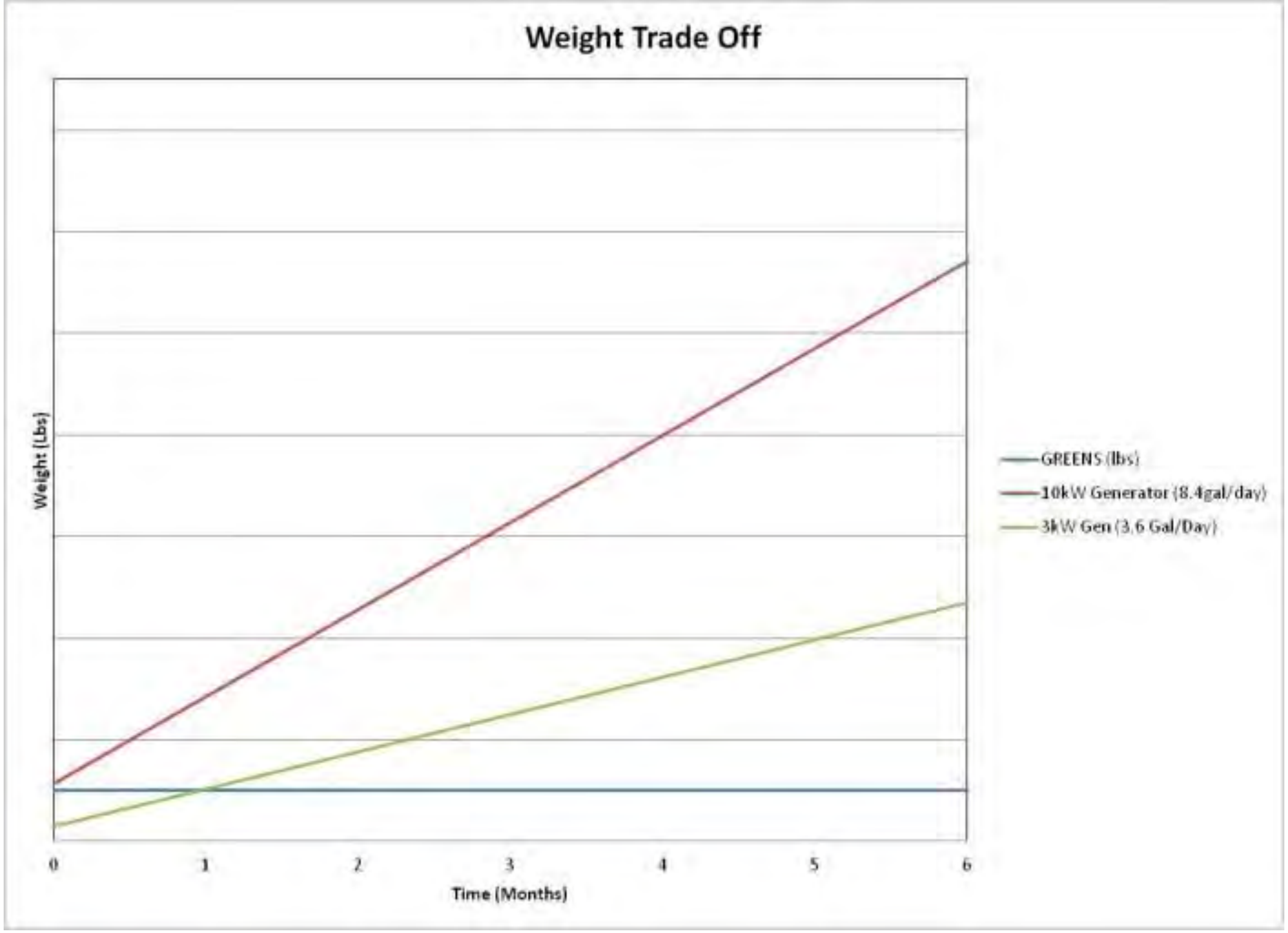
Cost with maintenance payback is ≥ 2 years vs. generators

Why GREENS?



Require less maintenance man power vs. generators

Why GREENS?



Weight payback is ≥ 1 month vs. generators

SPACES

- Current Solar Power Adaptor for Communications Equipment (SPACES) highly successful in deployment to OEF

- Next generation system will be required

- Future capability set (notional) to include:
  - < 10# weight (less battery, case)
  - Multiple folding panels
  - BB-2590/U battery charger
  - AA battery charger
  - USB power port
  - AN/PRC-152, -153, -117F adaptors
  - DC-AC inverter
  - AC charging plug, DC NATO plug
  - Hard case for full suite
  - Soft case for deployed sub-set
  - Backward compatible with SPACES

Renewable Sustainable Expeditionary Power (RSUP)

- ONR Program to build a trailer mounted hybrid renewable energy system
- 3 – 5 kW
- TRL 6 by 2015
- Shall employ sustainable energy strategies
- 40% fuel savings
- Focus Areas:
  - Fuel consumption
  - Noise levels
  - Cost of ownership
  - Maintainability
  - Deployability

Questions?





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Alternative Energy Based Expeditionary Power Solutions

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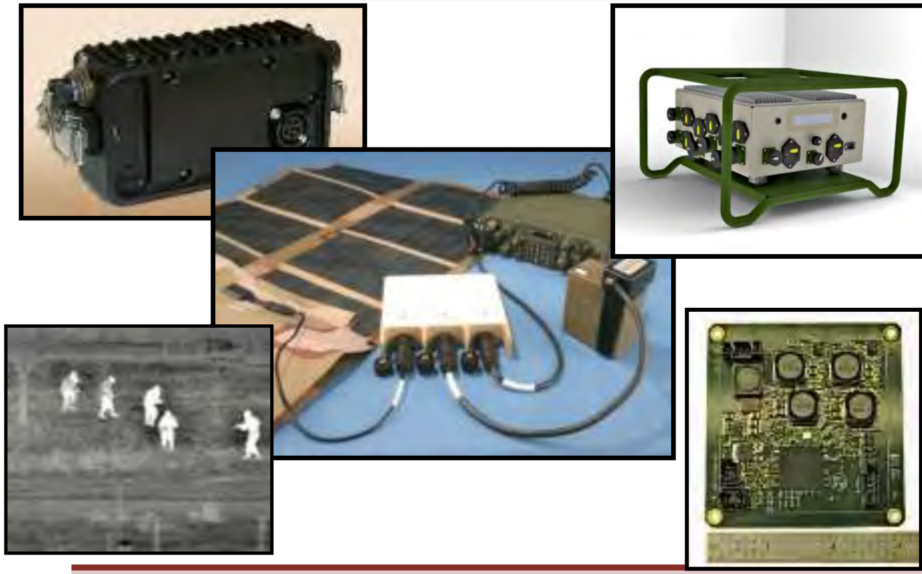
Presented at the Joint Services Power Exposition
Myrtle Beach, SC
May 4, 2011

Agenda

SPACES Training
Photo by Sgt. Heather Golden; used with permission.

- Introduction
- StarPower™ technology and applications, including SPACES
  - Man-portable
- StarBase™ technology
  - FOB-level
- High Efficiency Renewable Energy System (HERES)
  - New USN SBIR Phase I Program
- Questions

Aerospace Expertise Directly Benefits Solar Products



Vision: Deliver innovative solutions to our customers on budget and ahead of schedule.

Products and Services: Military power inverters, tactical radio adapters, high speed digital electronics, STE, space electronics, EO/IR subsystems, cryogenics, and advanced thermal management.

Key Customers: USMC, Missile Defense Agency, US Army, Navy, and Air Force, Teledyne, Raytheon, GenCorp Aerojet.

Iris Technology Corporation

Corporate Overview:

- Established in 1986
- TS/SCI Clearances
- Located in Irvine, California
- 25 Employees ~ $10M Revenue
- Classified as "Small Business"
- DLA Best Value Award 5 years

Our unique combination of ***high volume military production*** and ***custom electronics for space*** yields a unique blend of talents and capabilities.

Talent
Technology
Cost Effective Solutions

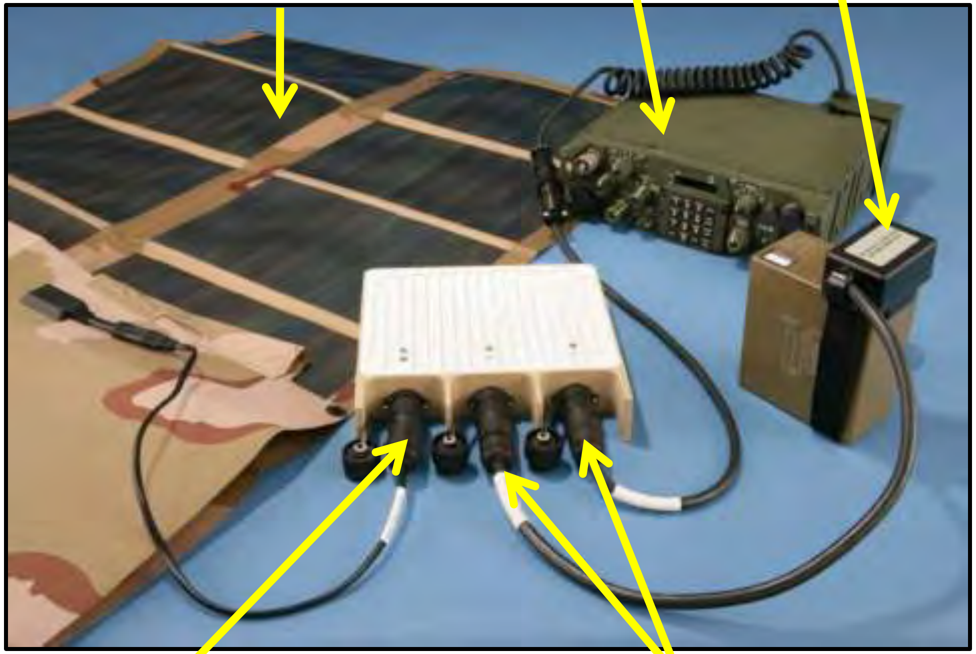
Our corporate culture is characterized by innovation, customer focus, fast response, technical excellence, and a sense of patriotic duty.

StarPower™

Mobile, Lightweight, and Rugged
- 2.6 pounds
- 8 x 8 x 1.6 inches

Versatile Power – Combat Ready
- 9 to 35 VDC input
- 12 to 32 VDC output
- Up to 320 W output power
- Supports multiple battery chemistries
- Supports mixed state-of-charge

Power Anywhere
- Acts as a uninterruptable power supply (UPS) when configured as shown



USMC SPACES (Solar Portable Alternative Communications Energy System)

Photo taken by Gunnery Sgt. William Price
Helmand Province, Afghanistan

Product Objective: Provide a mobile solar power solution for the warfighter

Customer: USMC (PM: Malar Motley)

Dates: 2007 to Present

Capabilities: Receives power from solar panels or other DC source to charge batteries and power equipment

Quantity Delivered: Over 2000 to date; over 1300 delivered to combat theatre

Training @ Camp Pendleton

USMC Raves about SPACES

- "Biggest asset"
- "Help save lives in combat zones"
- "Durable, light weight (and) user friendly"
- "We all see how crucial and important renewable energy is"
- "It lessens the likelihood of Marines being killed"


India Company, 3/5 Dark Horse Marines use solar power to brighten mission accomplishment

'Going green' with SPACES could save lives

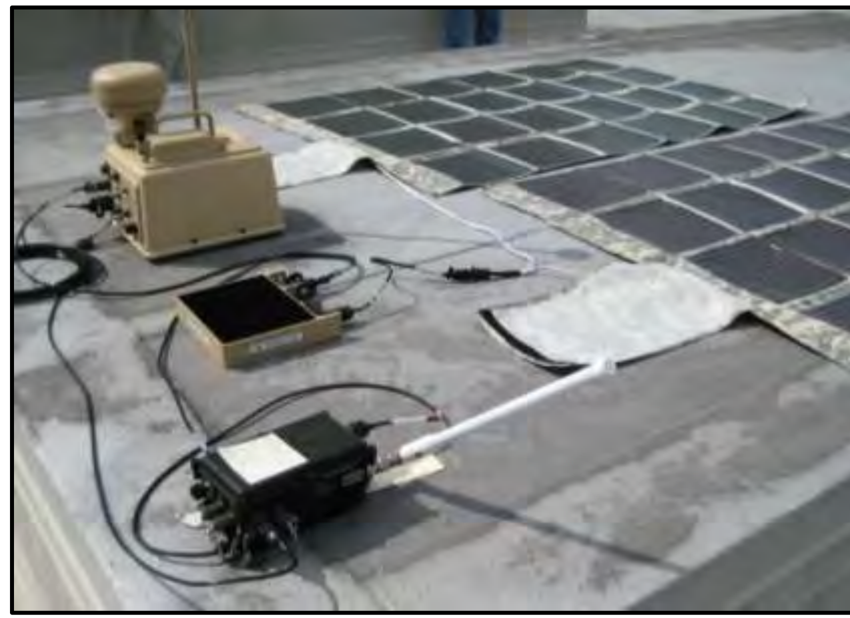
My number in the Company DOC is XXX-XXXX

Thanks Sir.

Other Applications of SPACES Equipment

SPACES, originally developed to support communications equipment, has proven readily adaptable to numerous other applications.

Surefire HellFighter®: Heavy Gun WeaponLight



Joint Biological Tactical Detection System (JBTDS)

IRIS TECHNOLOGY

SPACES Has Even Been Scaled Up to Support Over 300W Applications

M777a2 Howitzer

Photos taken November 2010 at 29 Palms. SPACES provided remote power to M777a2 howitzers during a weeklong artillery training exercise for 2nd Battalion, 10th Marines.

StarPower™ → Merlin™ Radio Power Adapters

Merlin-3™: AN/PRC-117G RPA

- **Uses standard full-size batteries and existing battery box**
- **Hot swap capable**
- **SPACES interoperable**
- **Merlin-2TM (AN/PRC-117F RPA) also available**

Merlin is basically StarPower™ packaged in a specific form factor and designed for extremely low EMI.

IRIS TECHNOLOGY

StarBase™

StarBase™ System

- Controller, batteries, solar panels, and generators
- Functions as a DC UPS
- Reduces fuel consumption with smart control over generator operation

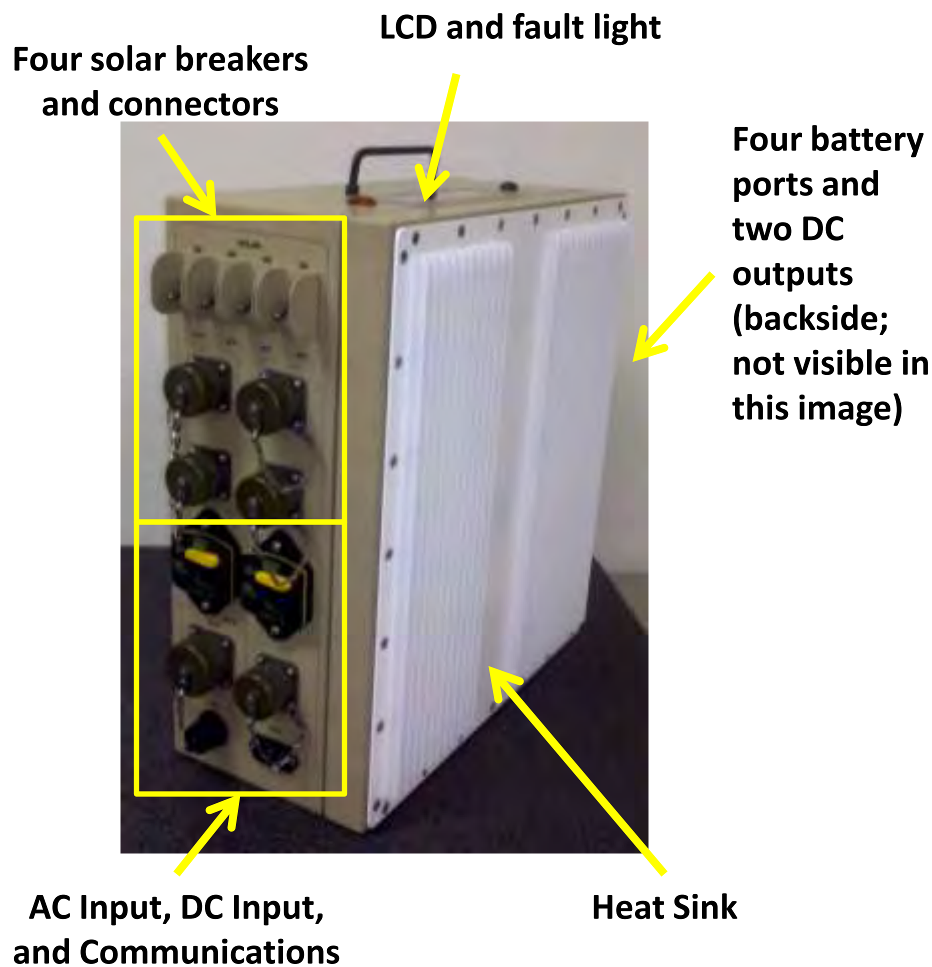
Controller Electronics

- 96-98% power conversion efficiency
- 3-kW input capable (2 kW solar + 1 kW generator)
- 1 kW peak output; 500 W continuous

Flexible Architecture

- Lithium ion or lead acid batteries
- Optimized load balancing
- Plug and play

Prototype "StarBase™" Controller



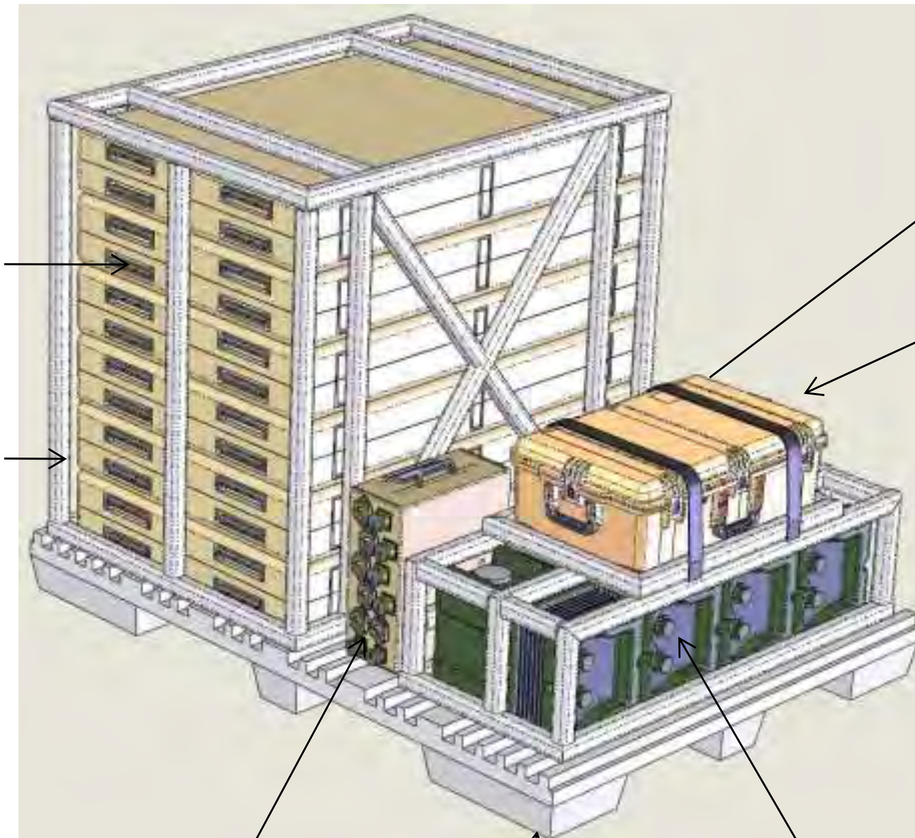
Comparison of StarBase™ System Options

Component/Capability	GREENS (USMC Program)	StarBase™ I (Present Technology)	StarBase™ II (Future Growth)
Controller			
AC Input Power Capacity	1.0 kW	1.2 kW	2.0 kW
DC Input Power Capacity	1.0 kW	1.2 kW	2.0 kW
Solar Channel Capacity (ea)	500 W (Qty. 4)	645 W (Qty. 4)	860 W (Qty. 4)
Battery Channel Capacity (ea)	500 W (Qty. 4)	645 W (Qty. 4)	860 W (Qty. 4)
Peak Output Power	1 kW @ 24VDC	2 kW @ 28 VDC	2 kW @ 28 VDC
Batteries - Low Cost Configuration			
Type	AGM	AGM	AGM
Quantity	8	10	10
Energy Capacity	1.2 kW-hr ea (9.6 kW-hr TTL)	1.2 kW-hr (12.0 kW-hr TTL)	1.2 kW-hr (12.0 kW-hr TTL)
Batteries - Low Mass Configuration			
Type	Li-Ion	Li-Ion	Li-Ion
Quantity	4	5	3
Energy Capacity	1.8 kW-hr ea (7.2 kW-hr TTL)	2.5 kW-hr (12.5 kW-hr TTL)	4.4 kW-hr ea (13.2 kW-hr TTL)
Solar Panels			
Quantity	8	12	12
Power Capacity	215 W/ea (1660 W TTL)	215 W/ea (2580 TTL)	215 W/ea (2580 TTL)
System			
Typical daily solar (6 hrs @ peak)	9.9 kW-hr	15.48 kW-hr	15.48 kW-hr
Continuous power	300 W	500 W	500 W
Daily energy output	7.2 kW-hr	12 kW-hr	12 kW-hr
Daily battery charge (SOL-Load)	2.7 kW-hr	3.48 kW-hr	3.48 kW-hr

Packaging Example: StarBase™ Palletized Option

Six (6) Integrated Solar Panel with Case Assemblies (ISPCA); 12 panels total

Support frame for shipping



Inverter (behind batteries; not visible in this view)

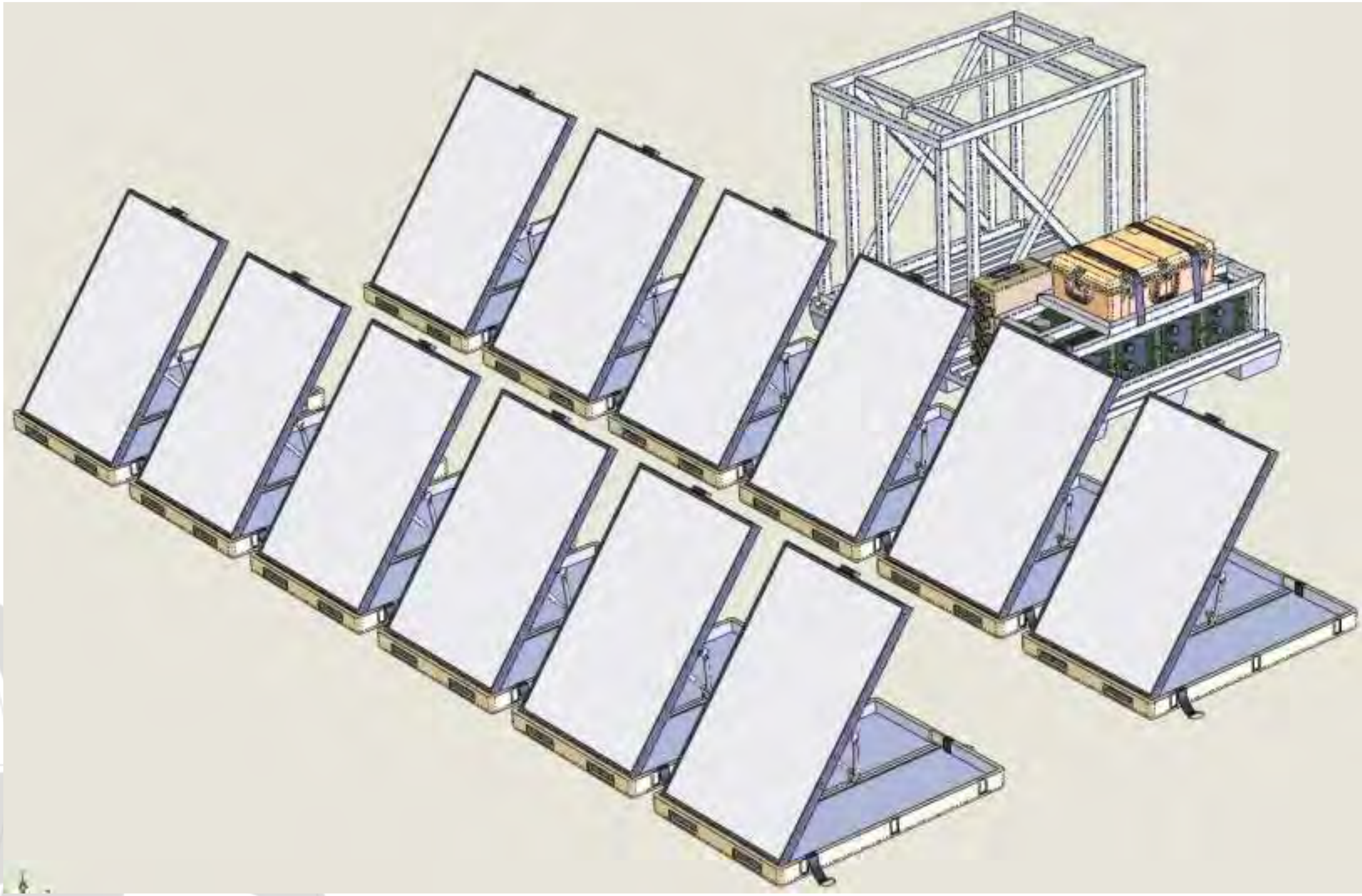
Storage for cables

Controller

Support pallet

Four (4) Li-Ion batteries

StarBase™ Palletized Option - Deployed

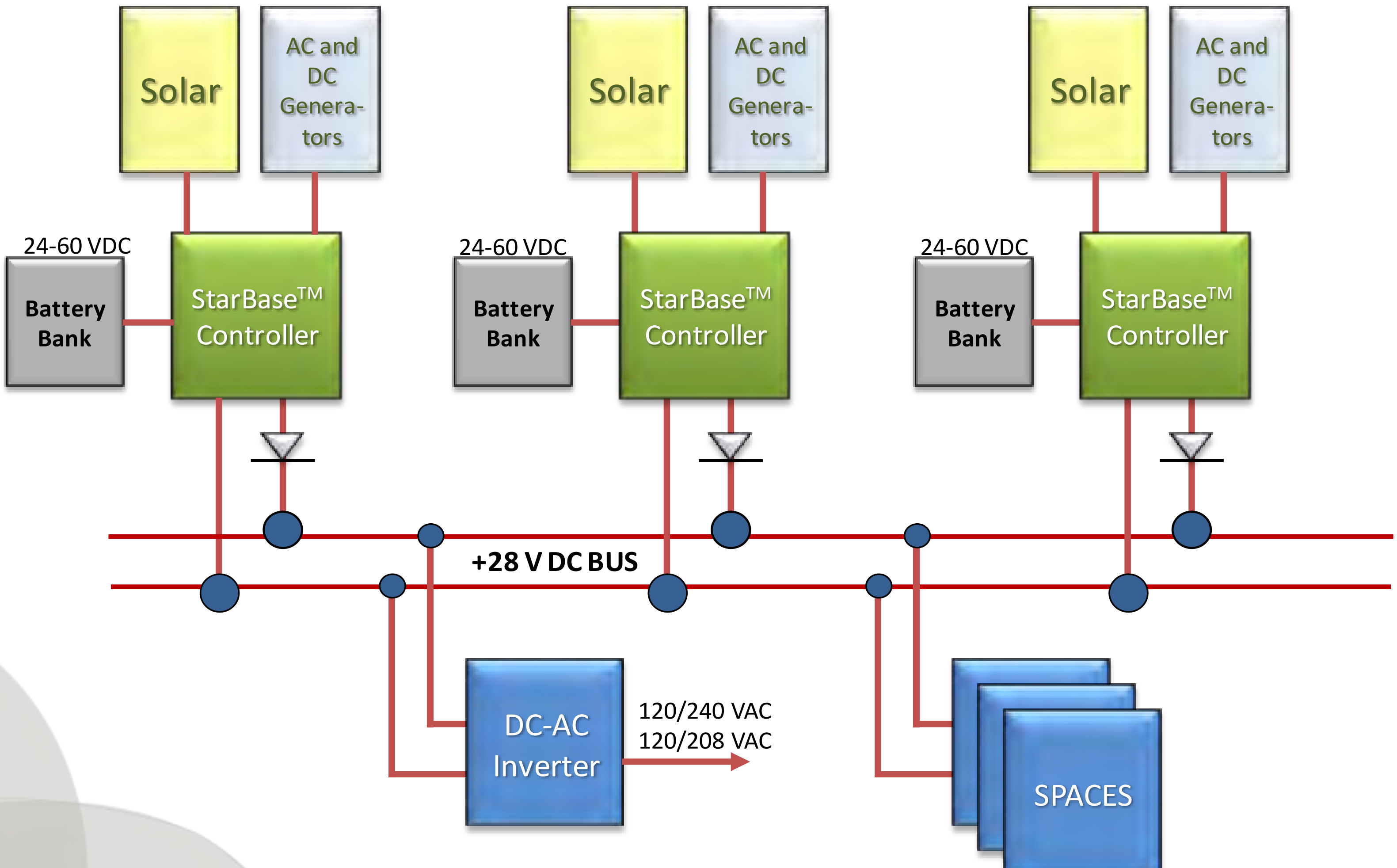


StarBase™ Controller Packaging Option

- Robust physical design
- Excellent thermal design
- Accessible connectors for fast setup
- IP-67
- MIL-STD-810F

For stand-alone applications, controller (solar generator) can be packaged in a frame with shock mounts, just like a traditional generator.

Integrated SPACES - StarBase™ Architecture



HERES (High Efficiency Renewable Energy System)

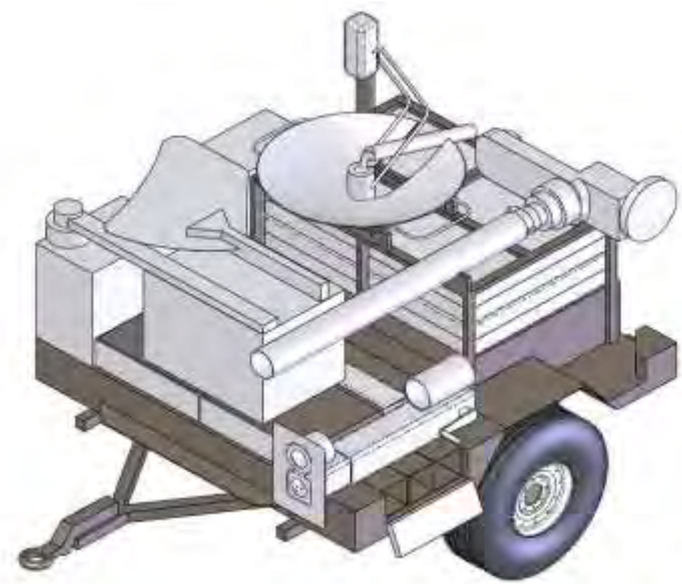
HERES - Deployed

Product Objective: 10 kW class, HMMWV trailer-mounted renewable energy system

Customer: USMC (PM: Justin Govar)

Dates: New SBIR Phase I Program; expected start in May/June 2011

Capabilities: Optimally utilize PV, wind, solar reflective, batteries, and generators to meet the HMMWV packaging and USMC power requirements



HERES - Stowed

Summary

- StarPower™ / SPACES is Technology Readiness Level (TRL) 9 technology
  - In theatre and performing very well
- Merlin™ products closely related to SPACES
  - Interoperable with SPACES
  - Electronics and software designs derived from SPACES
- StarBase™ now available for FOB-level alternative energy needs
- HERES will build on StarBase™, introducing additional alterative energy technologies beyond photovoltaic

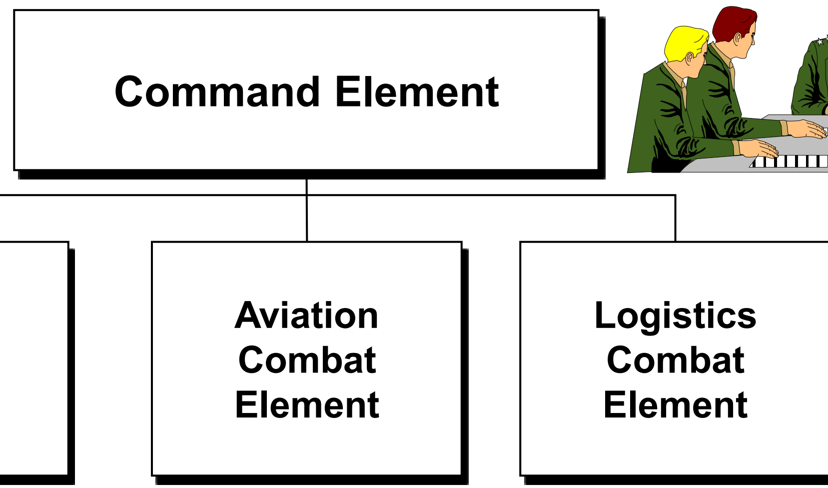
Joint Service Power Expo 2011
Small Unit Power Requirements

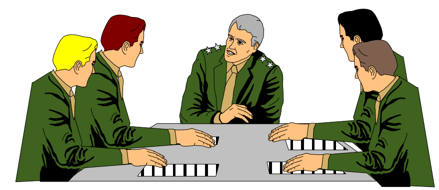
Purpose

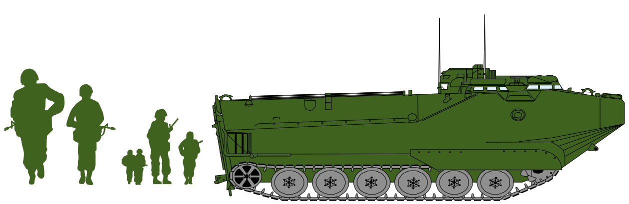
- Look at the Company and small unit power requirements
- Look at the camp structure in Afghanistan in relation to unit power requirements
- Review the alternative power equipment currently fielded to support Company sized units
- Impact of Renewable Energy Systems
- New requirements / opportunities

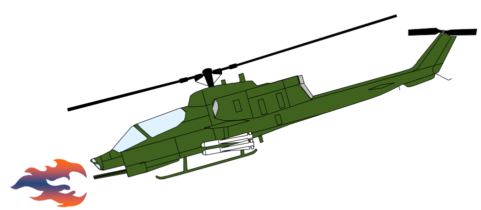
Marine Air-Ground Task Forces

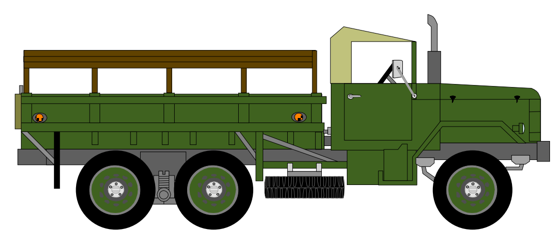
- Marine formations deploy as integrated MAGTF's of <u>various sizes</u>. The MAGTF brings Air, Ground, and Logistics support elements with them.
- There are four core elements of the MAGTF.









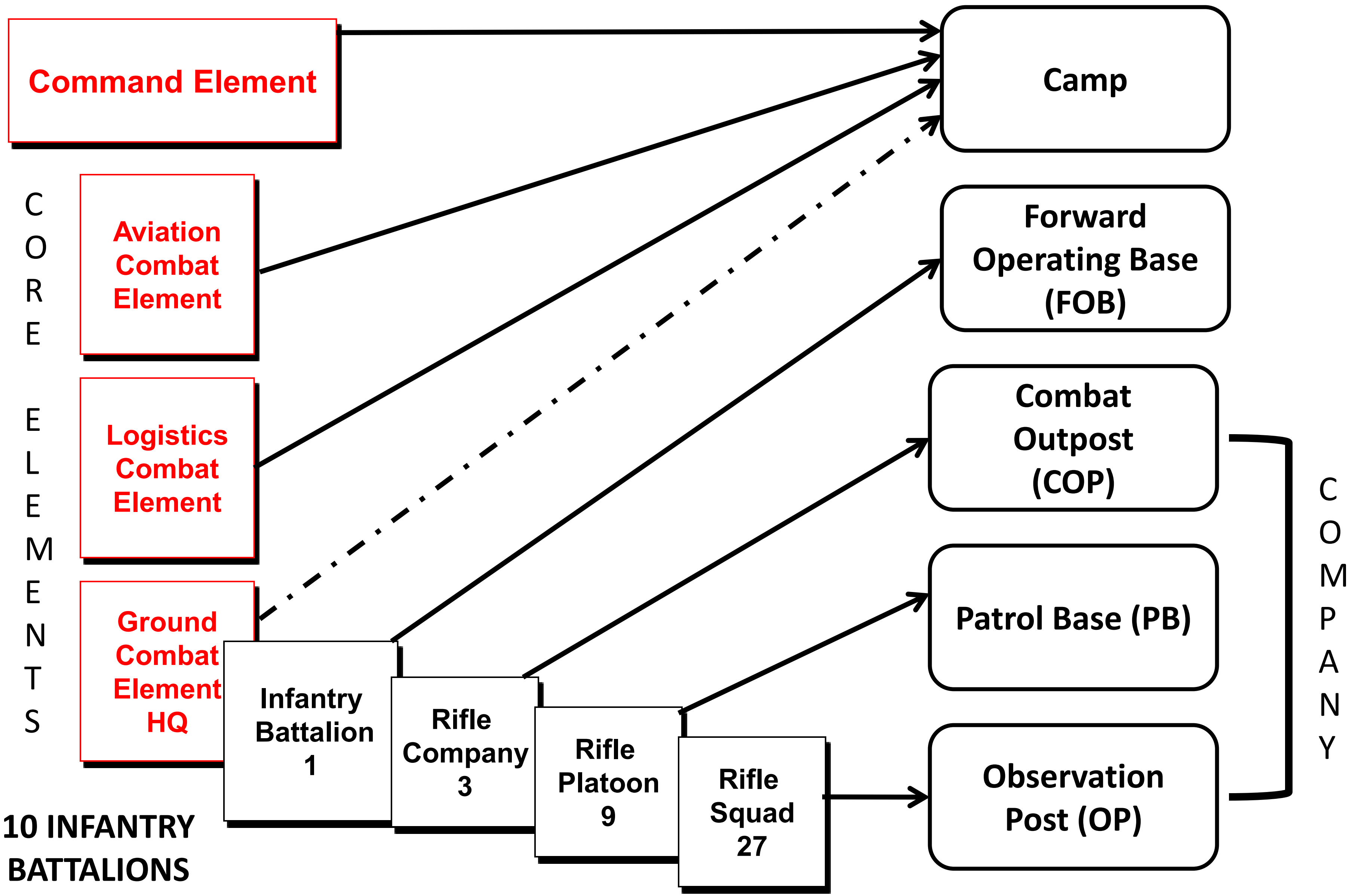


Marine Air-Ground Task Forces

- Power requirements depend on the size of the MAGTF and the size of the MAGTF is tailored to meet the needs of the mission.

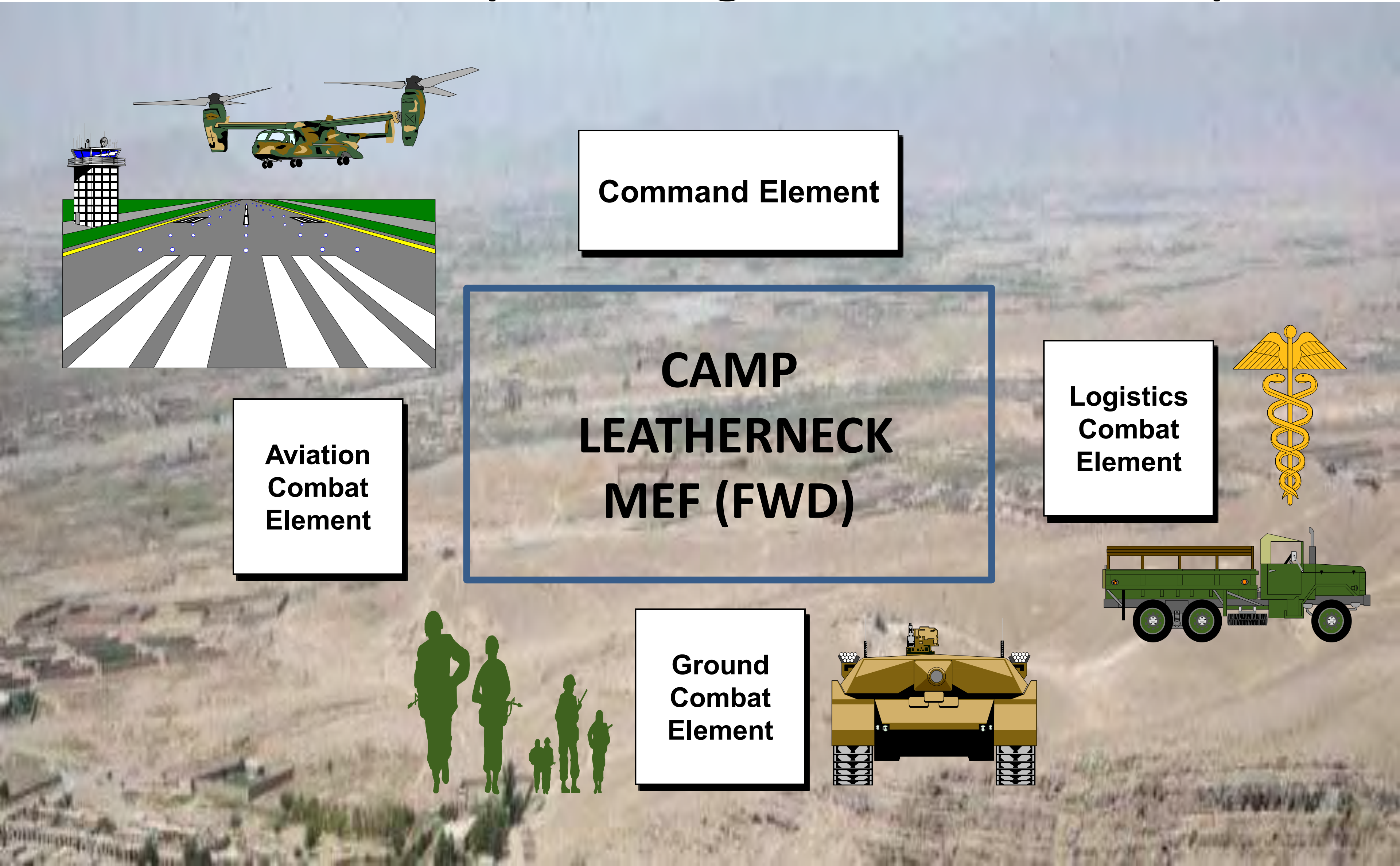
Special Purpose MAGTF	**As required**
Marine Expeditionary Unit (MEU)	**1500-3K Marines**
Marine Expeditionary Brigade (MEB)	**3-20K Marines**
Marine Expeditionary Force (MEF)	**20-90K Marines**

MAGTF Elements and Camps



The Entry Point
Forward Operating Base

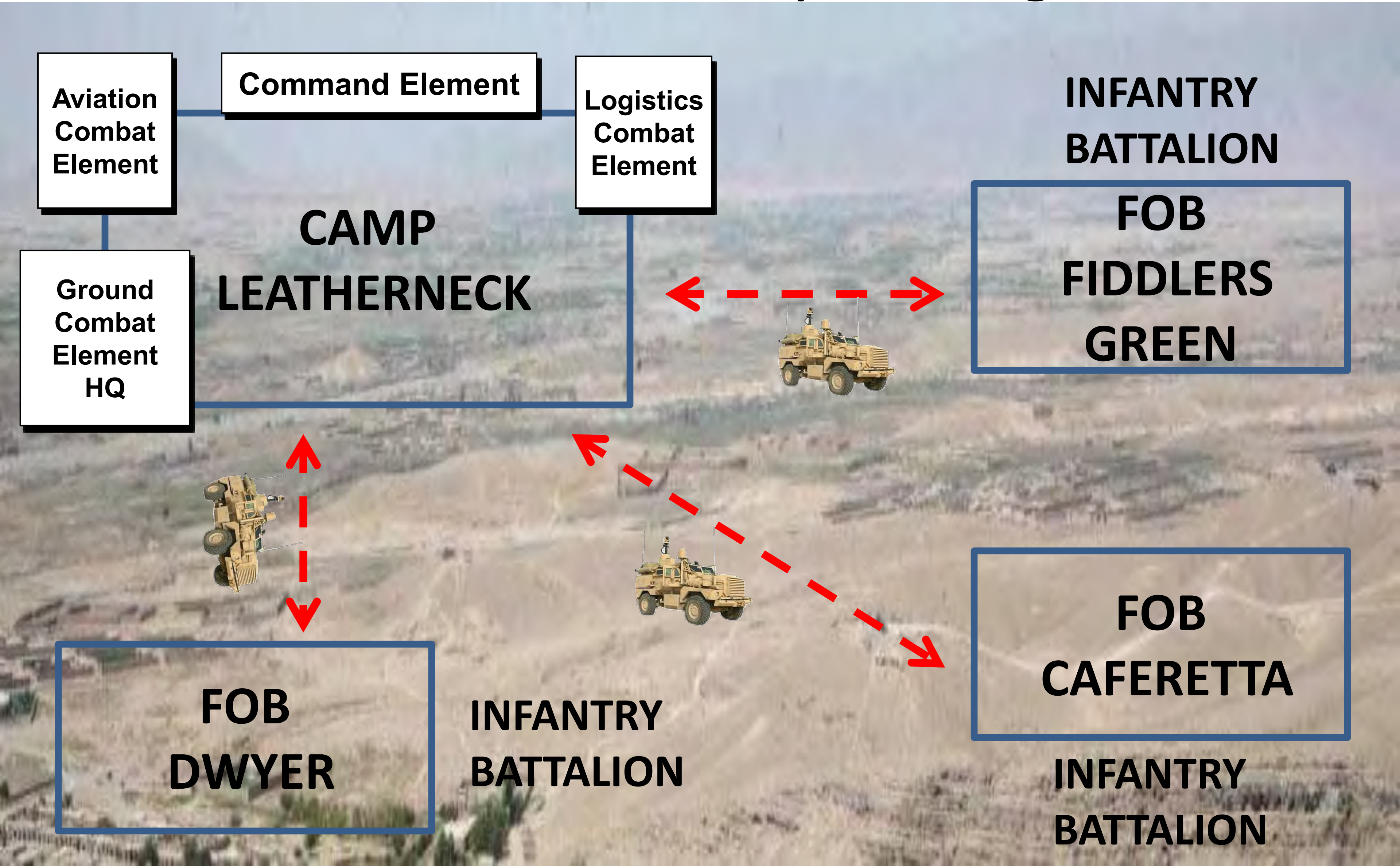
The Entry Point
Forward Operating Base and Camp



Characteristic's of the Expeditionary CAMP

- Mobile Electric Power readily available
- Tactical vehicle support readily available
- Airfield
- Hospital
- Large logistics support facilities

Extending Forward Presence with the Forward Operating Base



Tactical Convoys remain at risk to IEDs

Eliminate bottled drinking water

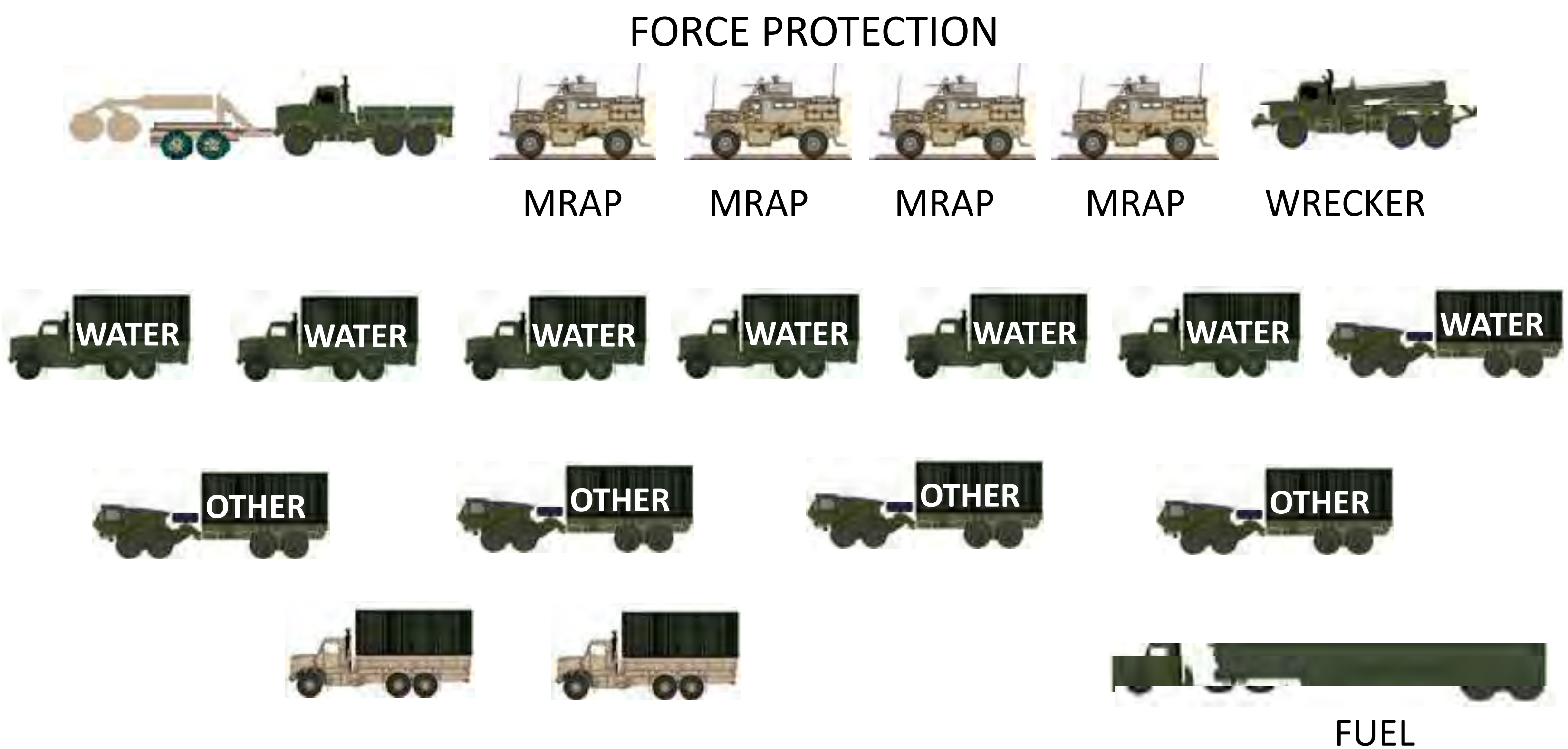
- Increase use of local water sources

Reduce high fuel consumption

- Optimize efficiency of generators
- Minimize waste of power and water
- Reduce overall power demand
- Employ renewable energy technologies

Standard CLB-8 Tactical Logistics Convoy

- Thirty percent (6 of 20) vehicles are for force protection
- Only one vehicle used for fuel
- Thirty-five percent (7 of 20) vehicles are for bottled water transportation



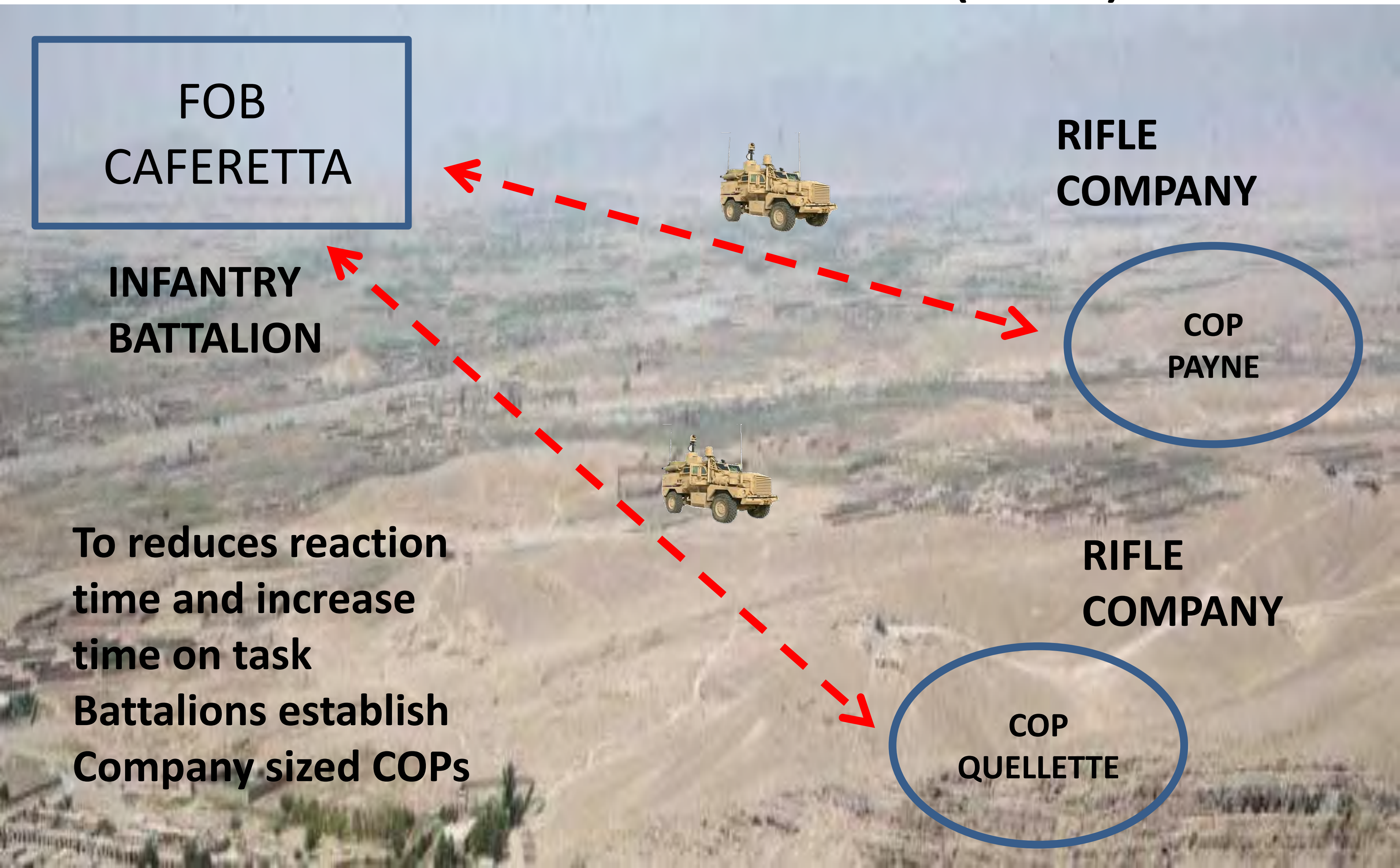
Resupply on the way

MRAP pushes a mine roller during a five-day convoy to provide resupply. During one resupply convoy it took nearly 40 hours to travel a mere 70 miles.

Characteristic's of the FORWARD OPERATING BASE

- Battalion sized organization
- Mobile Electric Power readily available
- Tactical vehicle support readily available
- May contain an airfield or FARP
- Limited medical support
- Limited utilities personnel for generator support / planning
- **Provides logistics support to COP's**

Forward Operating Base (FOB) and Combat OutPost (COP)



Characteristic's of the COMBAT OUTPOST

- Company sized organization
- Limited generator support (2kW to 3kW)
- Lack of trained generator mechanics
- Few generators running at optimal levels
- Unsupported commercial generators result in frequent loss of power
- Limited Tactical vehicle support
- Dependent on resupply from supporting FOB
- **Increased reliance on primary batteries**

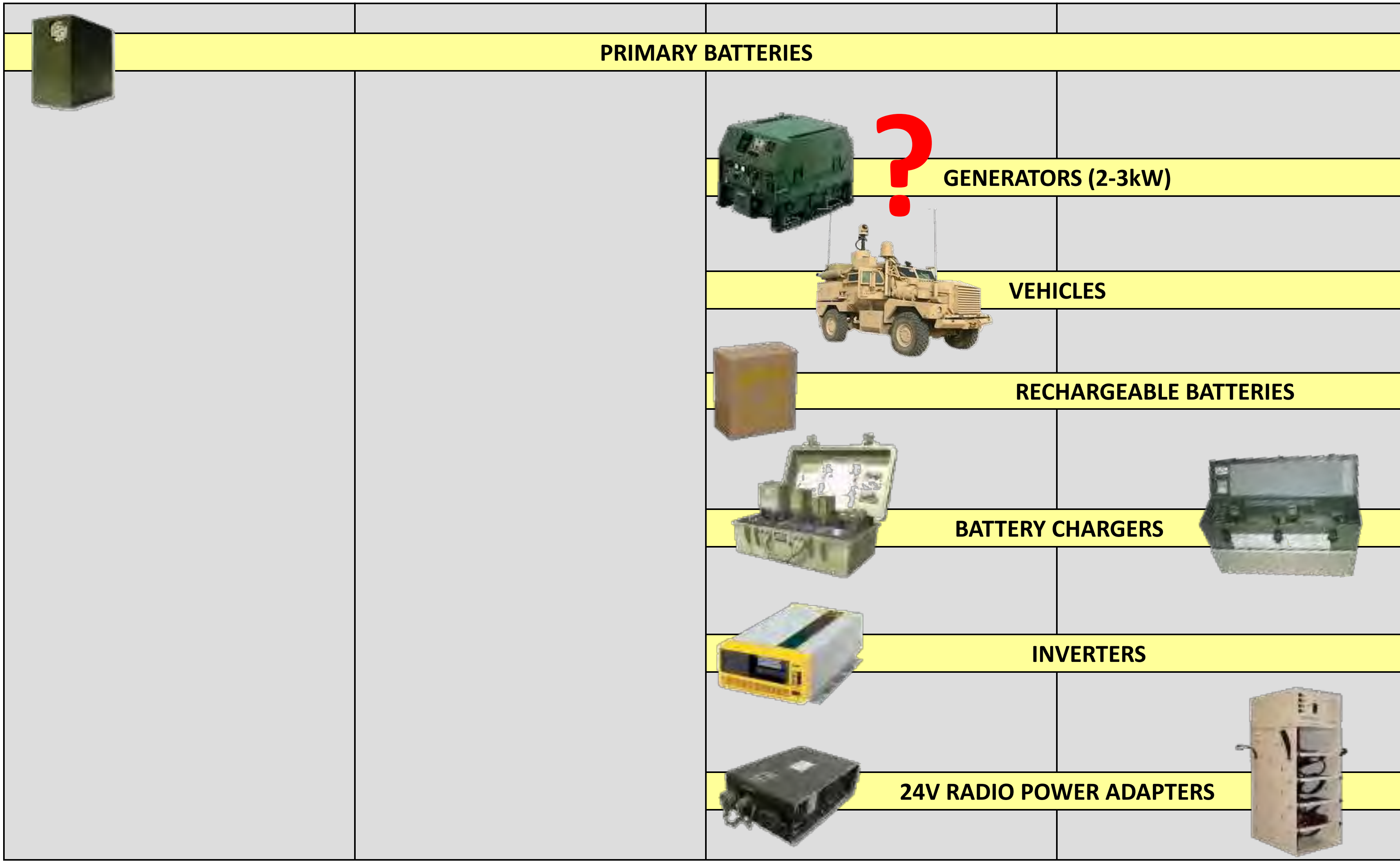
Primary Batteries and Re-supply

- Weight. 2 DOS battery load is 100-120 pounds, on average, 20 Lbs. per Marine in addition to combat load.
- Re-supply. Ties patrol to LOC's limiting abilities to push into enemy territory. Completely stalls operational momentum.
- Cost. One BA-5590B/U costs $60.00.
  - II MEF FY10 BA-5590 costs = 2.1 Million $
- Not always available. BA-5590B/U battery demands during OIF-1 (April – May 2003) peaked at 330,000 batteries per month and backorders quickly rose to over 900,000.

To reduce dependence on primary batteries you must have the capability to charge and maintain rechargeable batteries

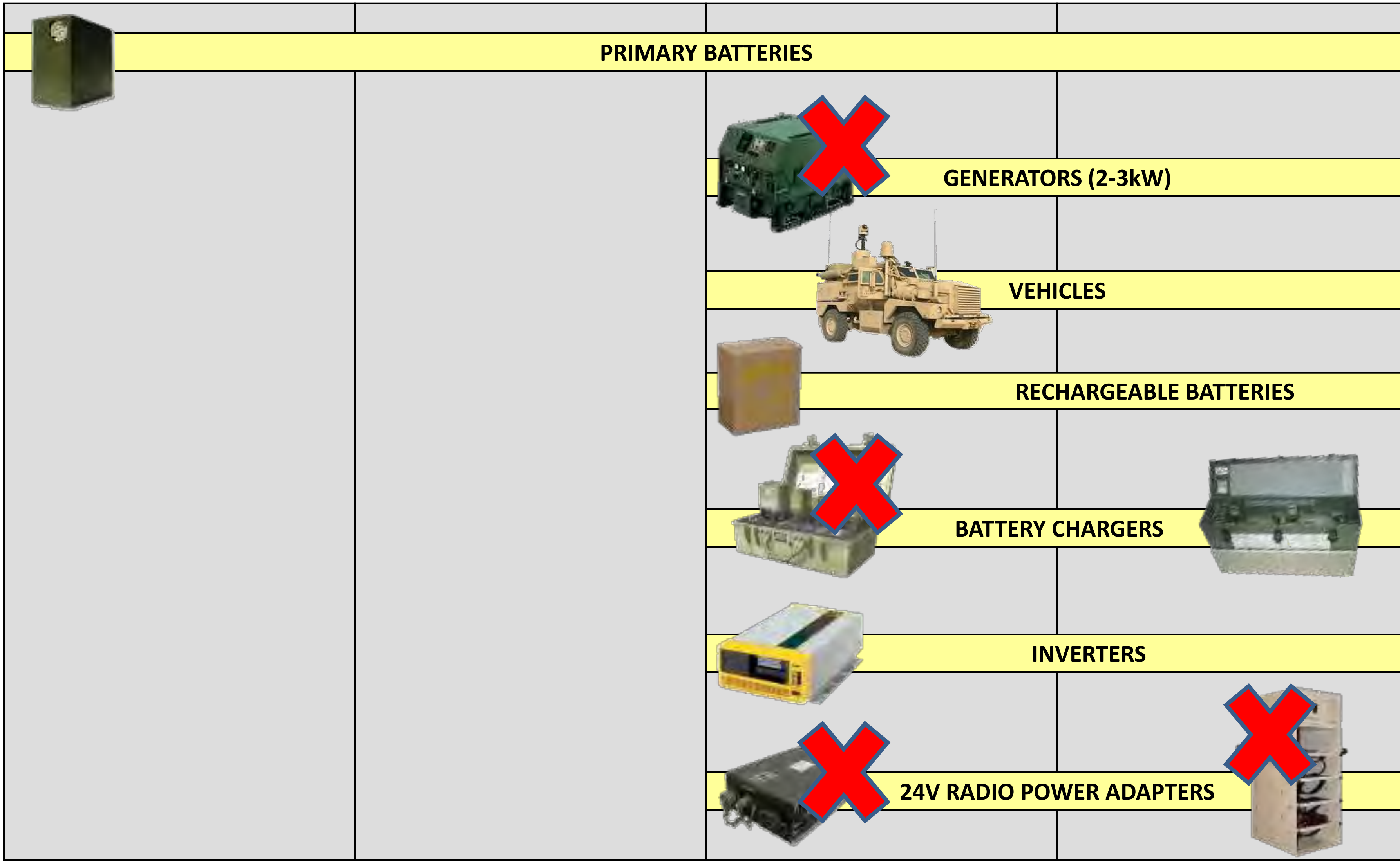
SQUAD PLATOON COMPANY BATTALION

PATROL BASE / OBSERVATION POST COP FOB



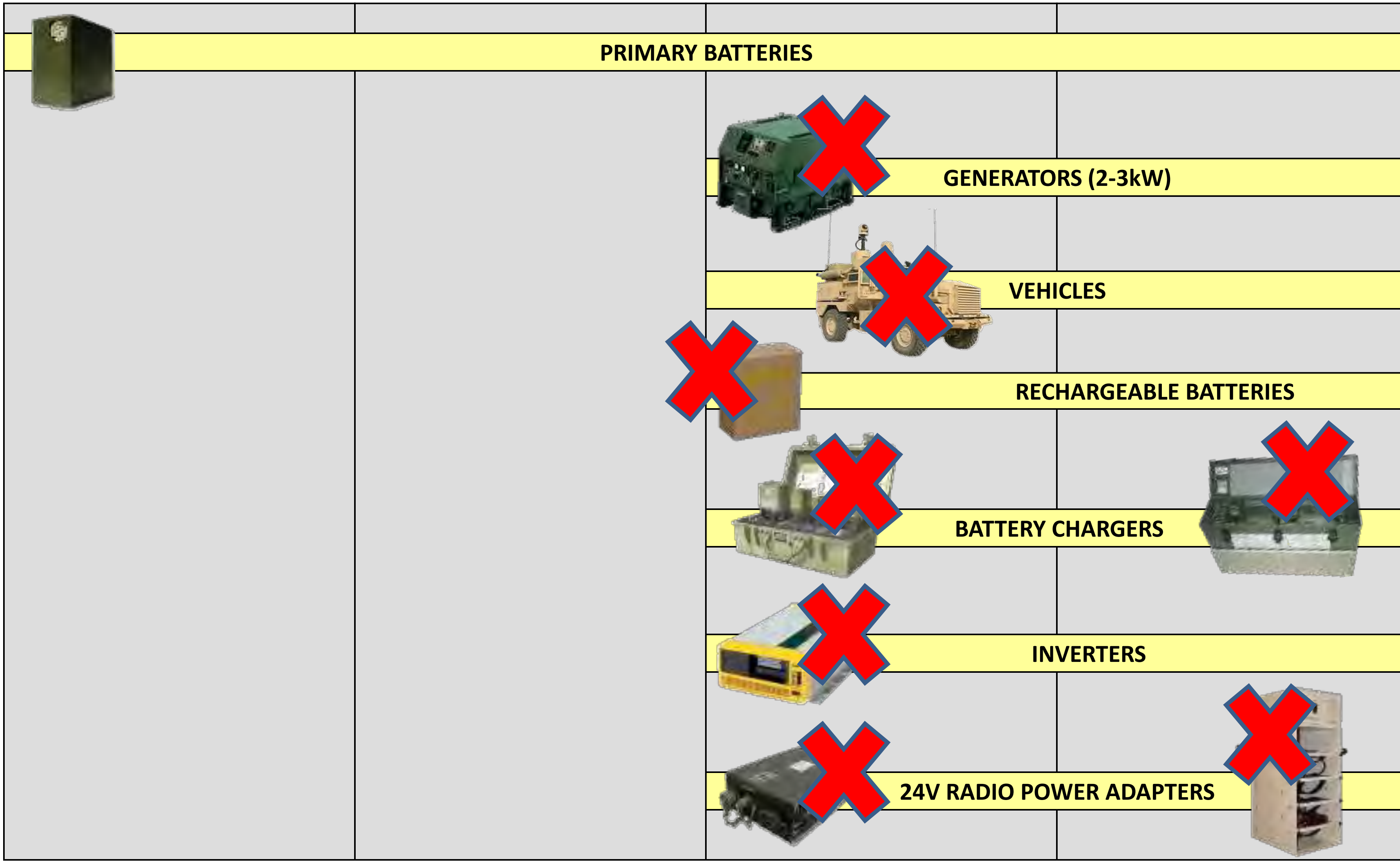
SQUAD PLATOON COMPANY BATTALION

PATROL BASE / OBSERVATION POST COP FOB

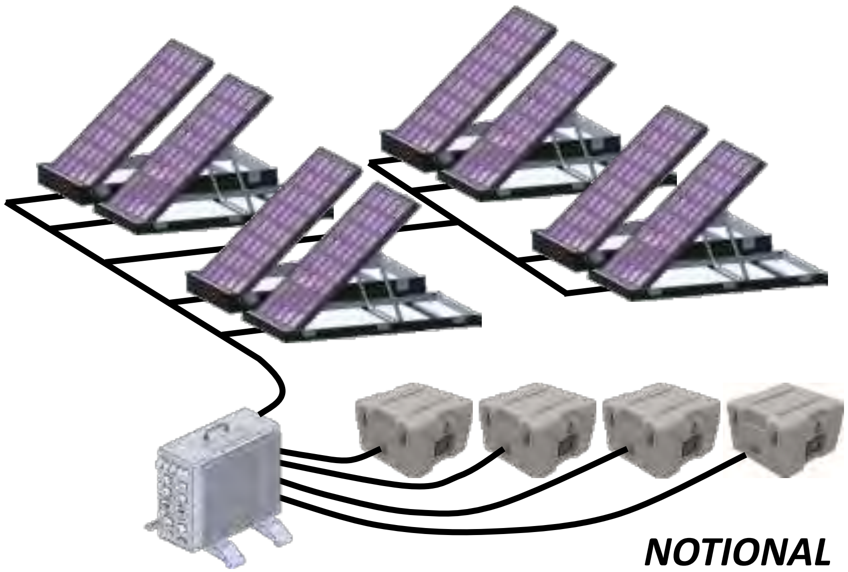


SQUAD **PLATOON** **COMPANY COP** **BATTALION FOB**

PATROL BASE / OBSERVATION POST



Ground Renewable Expeditionary Energy Network System (GREENS)



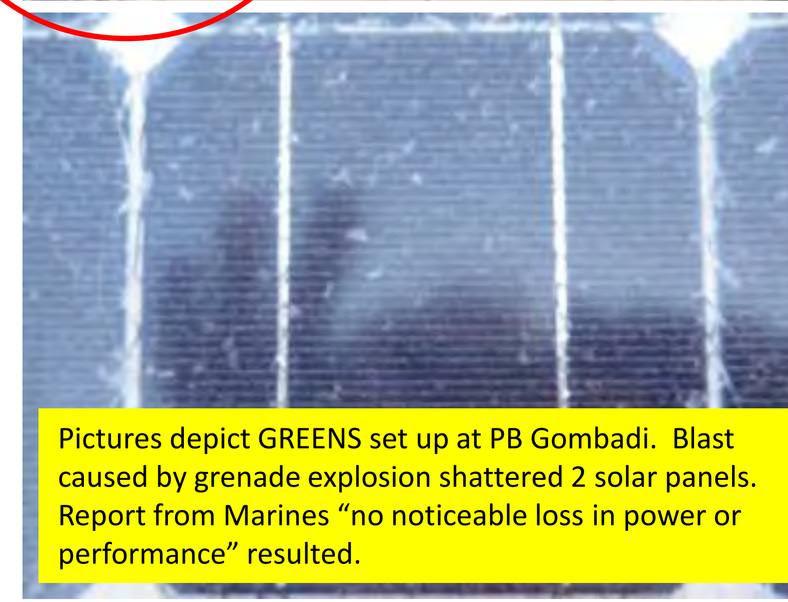
Capabilities Description

- Man-transportable devices with renewable energy collection and storage that can energize Comm-Elect equipment, sensors, and radios

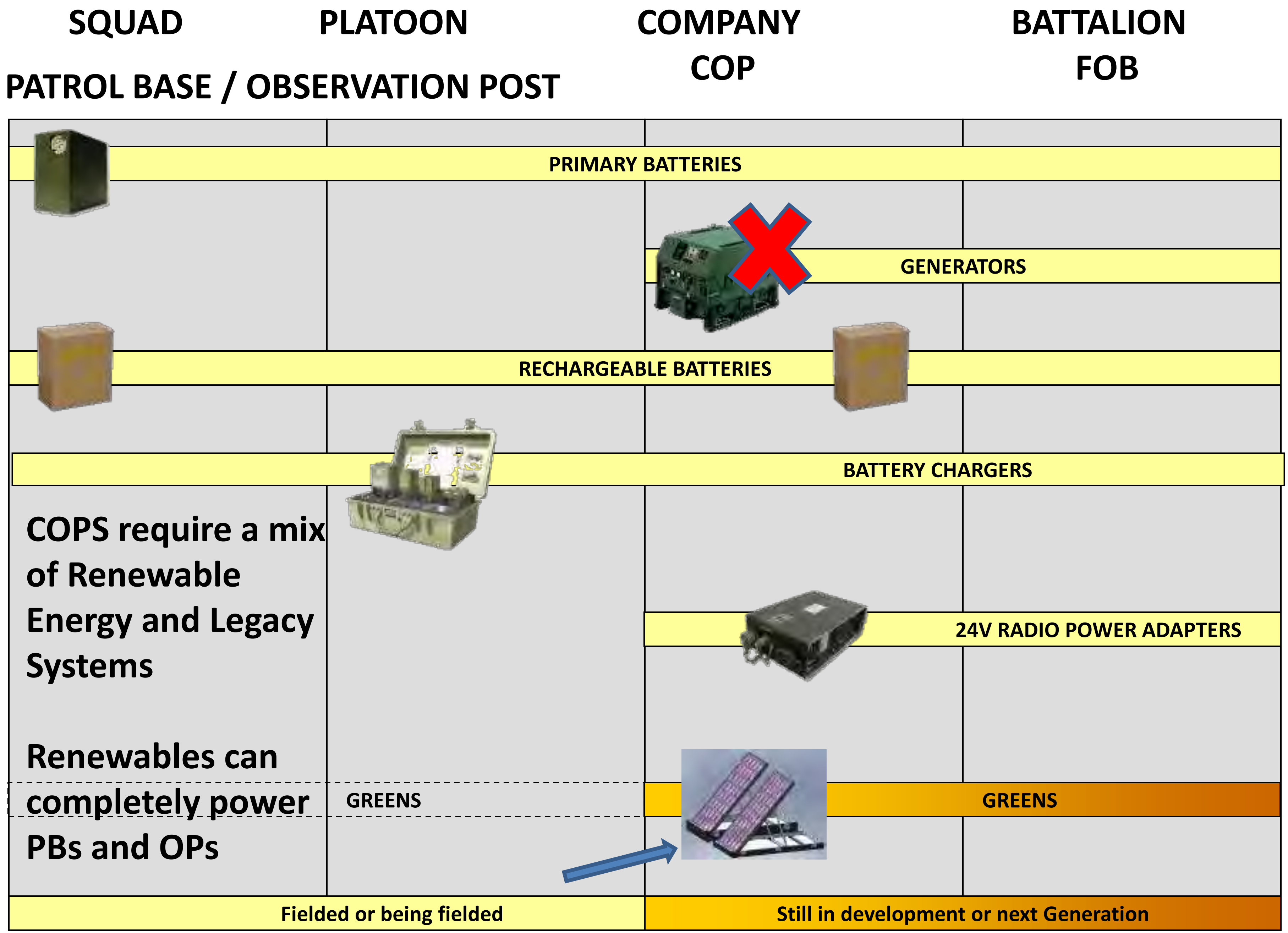
Technical Description

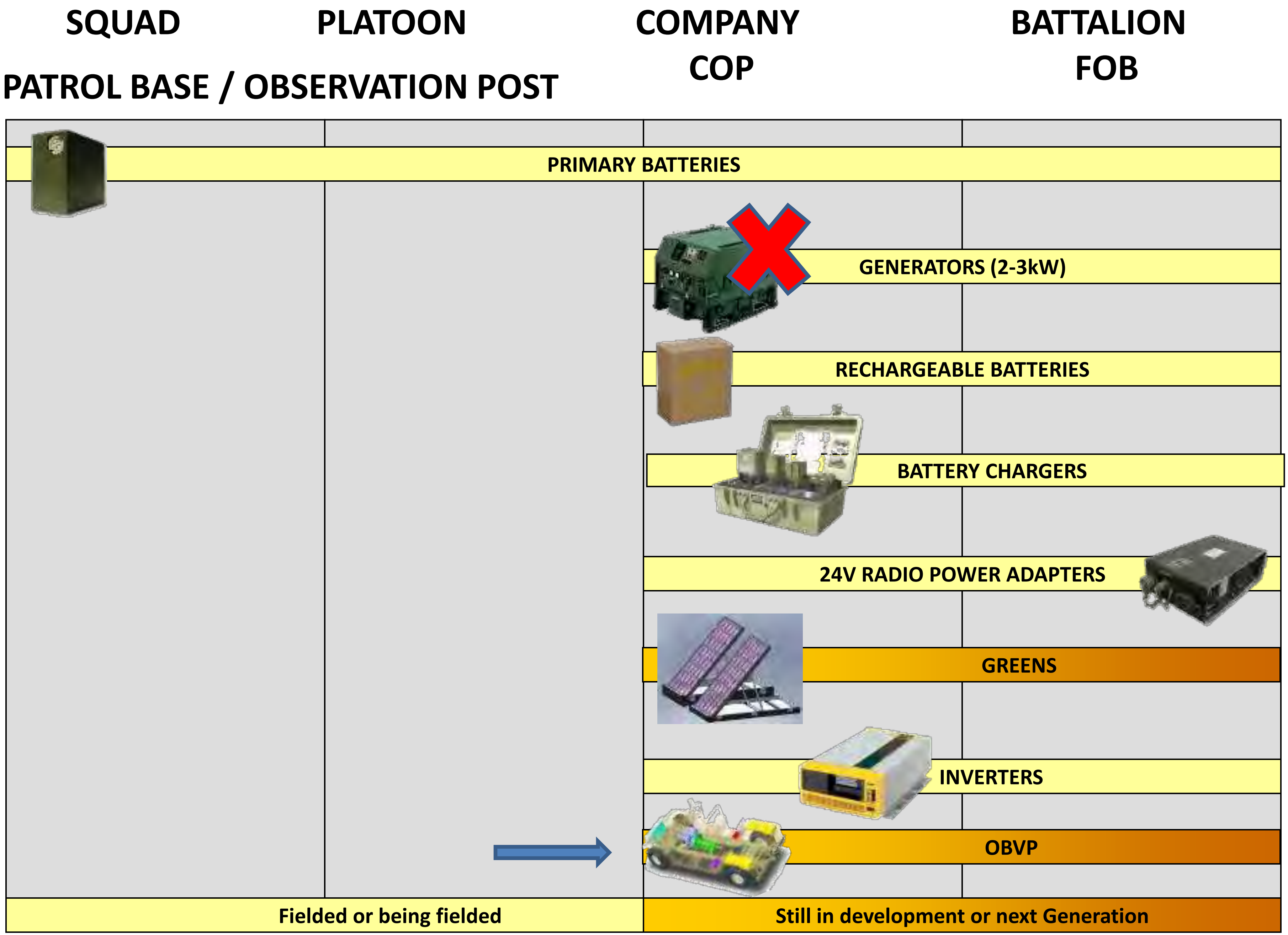
- Man-portable components
- Electrical output: 300 watt continuous 24 / 7
- 24 VDC output
- Key Components:
  - Batteries, Controller, and Energy Input sources

Solar Panel Durability – PB Gombadi

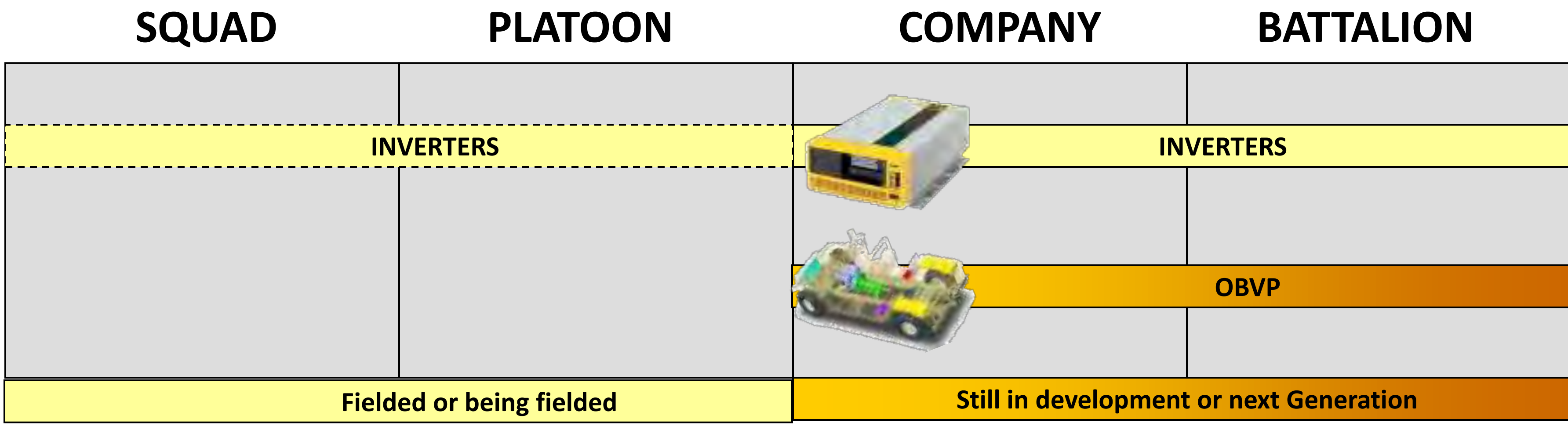


Pictures depict GREENS set up at PB Gombadi. Blast caused by grenade explosion shattered 2 solar panels. Report from Marines “no noticeable loss in power or performance” resulted.


SQUAD
PLATOON
COMPANY
COP
BATTALION
FOB
PATROL BASE / OBSERVATION POST
PRIMARY BATTERIES
GENERATORS
RECHARGEABLE BATTERIES
BATTERY CHARGERS
COPS require a mix of Renewable Energy and Legacy Systems
24V RADIO POWER ADAPTERS
Renewables can completely power PBs and OPs
GREENS
GREENS
Fielded or being fielded
Still in development or next Generation


SQUAD
PLATOON
COMPANY
COP
BATTALION
FOB
PATROL BASE / OBSERVATION POST
PRIMARY BATTERIES
GENERATORS (2-3kW)
RECHARGEABLE BATTERIES
BATTERY CHARGERS
24V RADIO POWER ADAPTERS
GREENS
INVERTERS
OBVP
Fielded or being fielded
Still in development or next Generation

On-Board Vehicle Power



QP-1800

OBVP - HMMWV

OBVP - MTVR

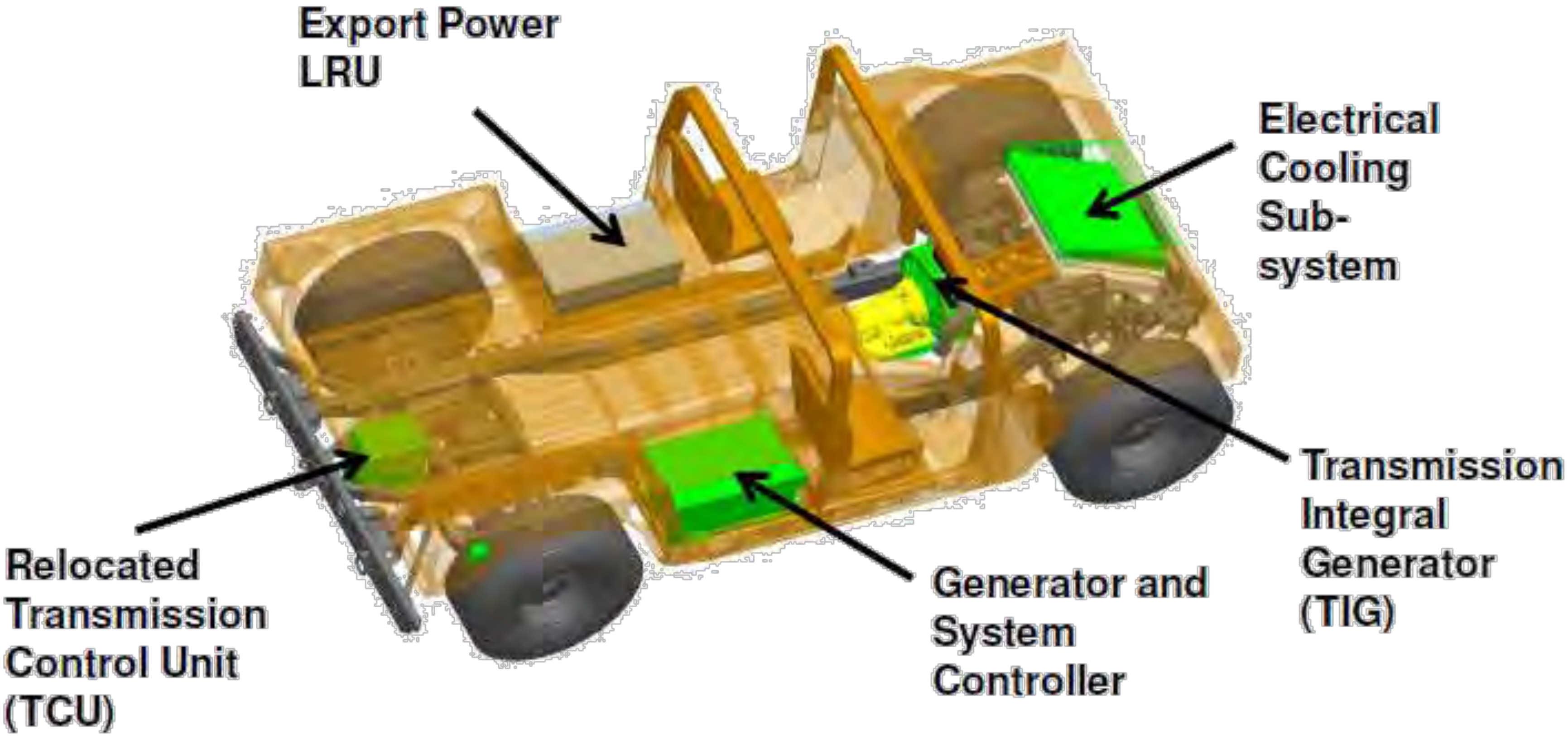
EMV 5-10 After Action KILO Company 3/5

• Kilo Company has been using a running M1114 with an A/C inverter to support power requirements for their COC. The **power demands have taken a mission critical gun truck out of the fight.**

• The **vehicle was not designed to run in idle for days.** This can put wear and tear on the vehicles components (engine, alternator, battery…) requiring maintenance.

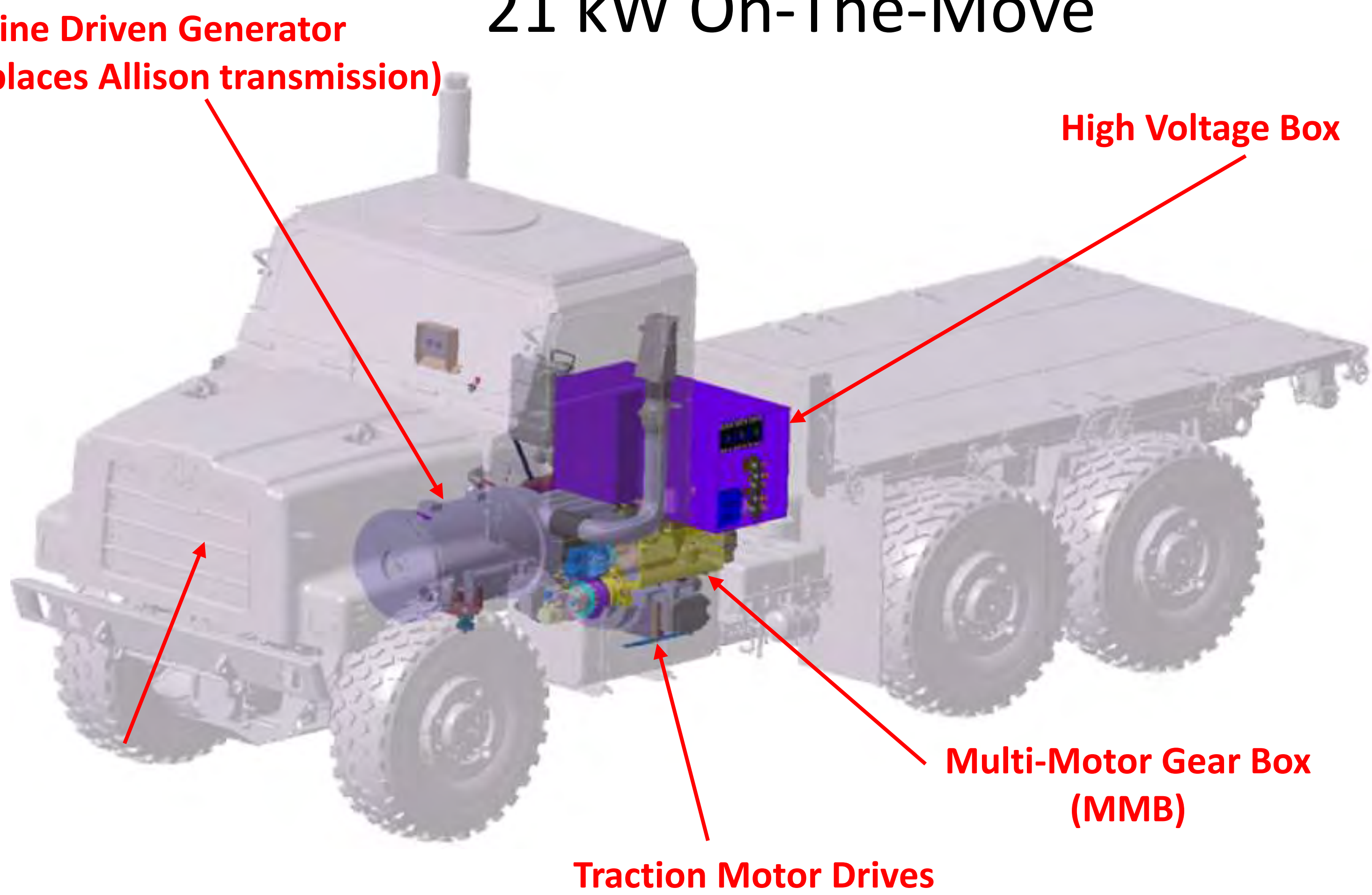
• The exact fuel consumption of a M1114 is unknown but an estimated figure is 5 gallon/day in idle . It has a 21 gallon tank and needs refuel about every 3-4 days.

On-Board Vehicle Power HMMWV
30 kW stationary
10 kW On-The-Move



Add generator between engine and transmission
QTY 15 to be delivered by the end of CY11

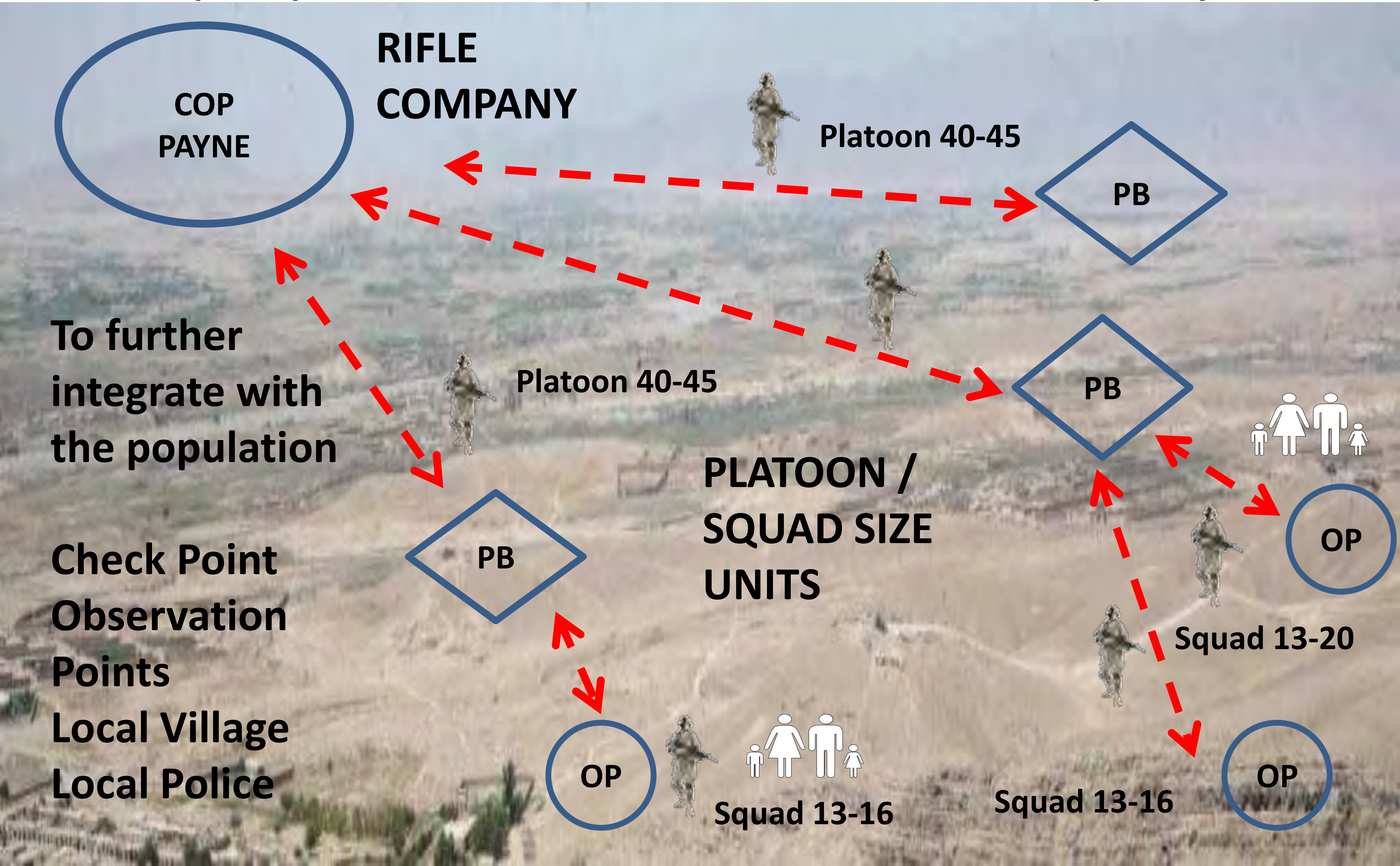
On-Board Vehicle Power MTVR
120 kW stationary
21 kW On-The-Move



Replace transmission with engine driven generator

QTY 6 to be delivered by the end of CY12

Combat OutPost (COP), Patrol Base (PB) and Observation Points (OP)



Characteristic's of the PATROL BASE and OBSERVATION POSTS

- No generator support
- No tactical vehicle support
- Dependent on resupply
- Dependent on primary batteries

Over 100 Patrol Bases and OP's that continuously change locations keeping the enemy off balance

Individual Power Requirements

COMM / OPTICS / SENSORS / LASER DESIGNATORS / POSITION LOCATION / PROTECTION

AN / PVS-17
AA Battery

AN / PVS-14
AA Battery

AN / PAS-13D
AA Battery

AN / PEQ-16A
Dl-123A Battery

Hand-held flashlight
AA Battery

MIOX Water Purifier
AA Battery

AN / PSC-13 D-DACT
Unique or AA Battery

DAGR
AA Battery

AN / PRC - 148 or 152
Unique Batteries

AN / PRC-153
Unique Battery

Quiet Pro Headset
Unique Battery

Squad Digital Camera
Unique Battery

AN / PRC-117F
BA-5590 / BA-5390 / BB-2590 Batteries

Rugged Laptop
Unique Battery




Challenges associated with PATROL BASE and OBSERVATION POSTS

- Large AO's
- Long duration patrols (8-10 days)
- Critical dependence on radios
- Carry 1-2 days + of supply
  chow / ammo / batteries / water
- **BATTERY RESUPPLY EVERY 48 HOURS**
- Re-supply ties patrols to LOCs stalling operational momentum

Rechargeable Batteries

Even if you choose to use primary batteries you still have to plan to support those radios that only use RECHARGEABLE batteries.

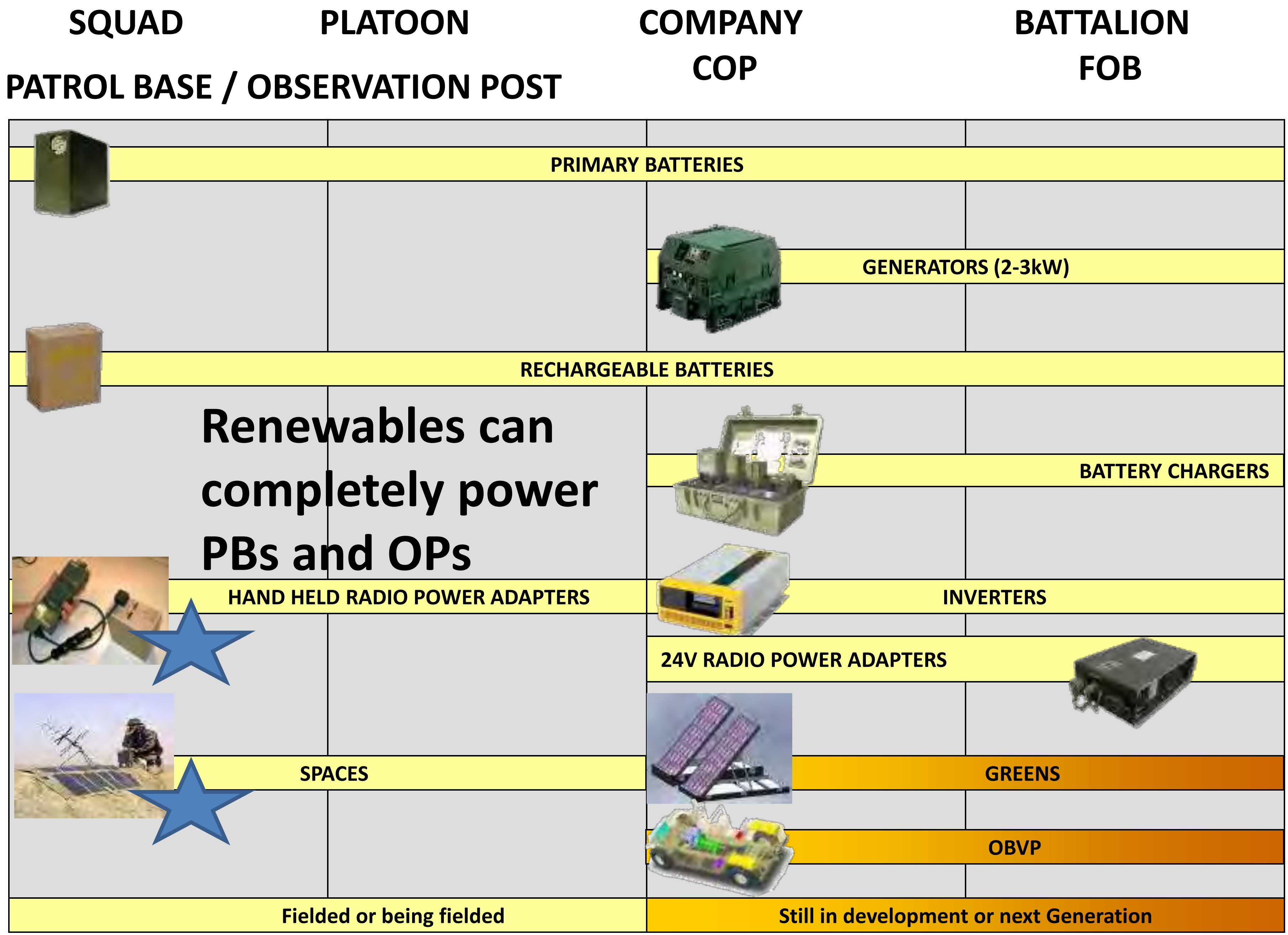
AN/PRC-148

AN/PRC-152

AN/PRC-153

Battery Resupply Every 48 Hours

- Operating AN/PRC-152 radios continuously powered for two days can requires 216 AA or 160 3 Volt batteries per radio



SQUAD
PLATOON
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PRIMARY BATTERIES
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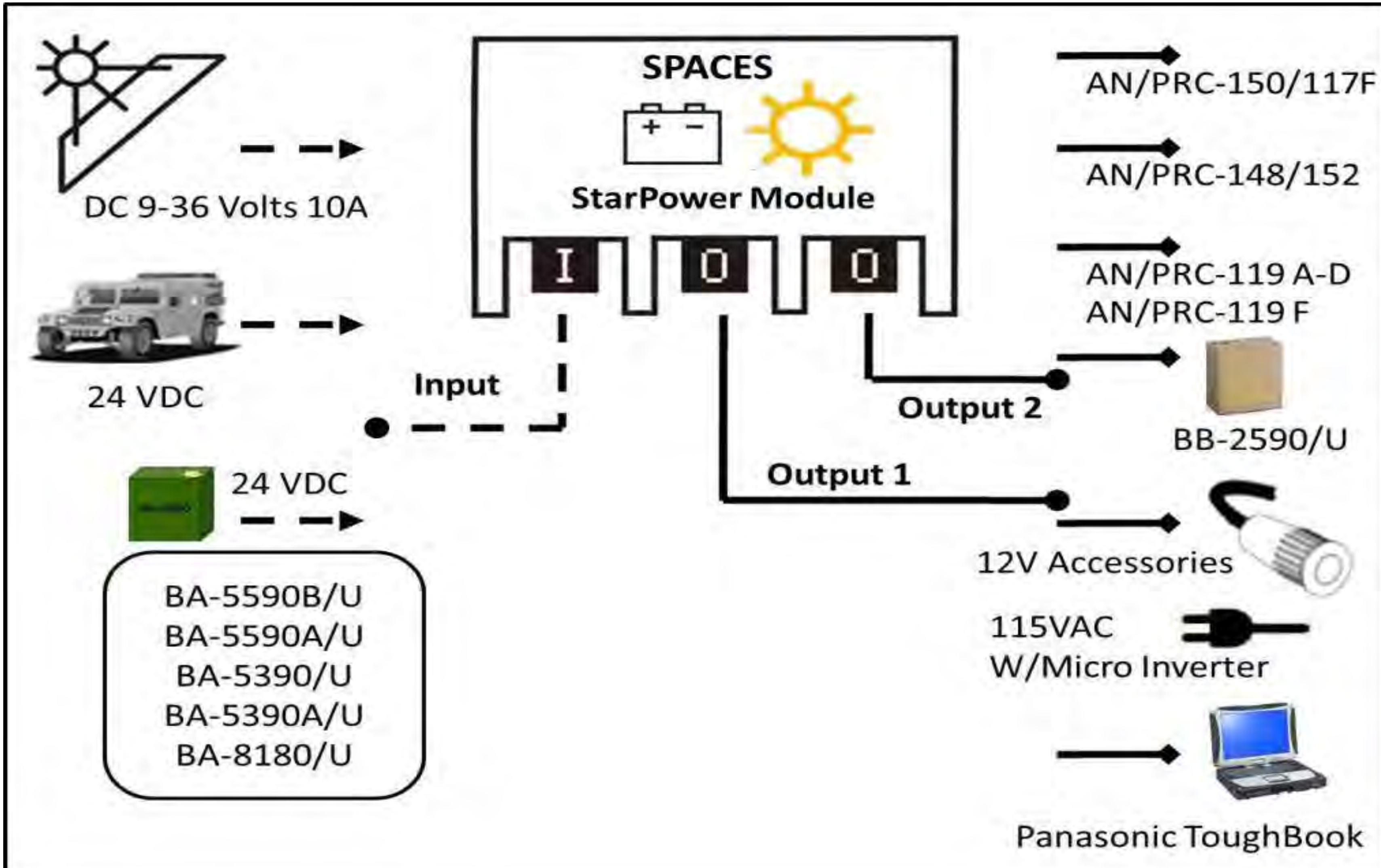
HAND HELD RADIO POWER ADAPTERS
INVERTERS
24V RADIO POWER ADAPTERS
SPACES
GREENS
OBVP
Fielded or being fielded
Still in development or next Generation

HH-RPA for the AN/PRC-152

SOLAR PORTABLE ALTERNATIVE COMMUNICATION ENERGY SYSTEM (SPACES)

The SPACES MSD collects energy from various sources (solar, DC/AC, Vehicle) to recharge BB-2590 batteries and to power external devices (12 and 24 VDC radios).

SOLAR PORTABLE ALTERNATIVE COMMUNICATION ENERGY SYSTEM (SPACES)




DC to AC
Inverter

Impact of Renewable Systems
3/5 dated January 2011

- 90 Days without the usual daily re-supply of batteries.

- 3 week patrol no batteries (norm every 2 days re-supply).

- Powered two patrol bases with renewable energy only.

- Fuel consumption reduced by 90% at the company level.

- Reduced weight by 700 lbs. and cost by $40K on one 3 week patrol.

New Requirements and Opportunities

- ❑ Smaller and more capable SPACES (renewable energy) systems (SPACES Generation II pending)

- ❑ Longer lasting primary batteries (new chemistries)

- ❑ GREENS (renewable energy) increased wattage and smaller footprint

- ❑ Small man-portable generators

- ❑ Tactical general purpose UPS

QUESTIONS

UNCLASSIFIED

High Power Density Turbine Based Generation Systems

Candent Technologies

Turbine Power Systems

NDIA

Joint Service Power Expo

Myrtle Beach, SC

02-05 May 2011

Presented by:

Hernando Munevar

Candent Technologies, Inc.
6701 W. Airport Blvd, Ste 190
Greenfield, Indiana 46140
317-336-4477 /4478

Candent Company Background

Candent
Technologies
Turbine Power Systems

About Candent Technologies: <u>A lean, experienced, and expert team</u> of technical, program management, and business development personnel.

Each member has 20 or more years experience in the design, development, qualification/certification, management, production and support of all types of gas turbines, but particularly small and low cost turbine engine systems, having been involved in the design and/or development of more than a dozen successful engines.

Sampling of Candent Team's Engine Experience

Allison Model 150

Low Cost - High Performance Turbojet designed and on test in 22 weeks

Under Armor APU for the M1A2 Tank

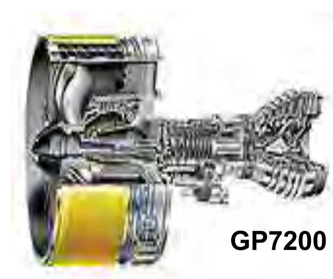
Low Cost Expendable Engines for Missiles and UAV's

Model 250

T800

T56/501

T406/AE1107/2100



GP7200

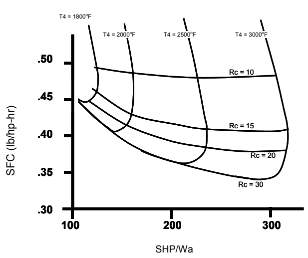
Strong background and knowledge base including small engines

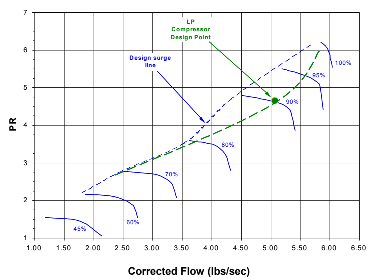
About Candent Technologies

- **Who we are:** *A lean, highly experienced, and expert gas turbine engine team, based in Mt Comfort, Indiana*
- **What we are doing:** *Presently developing high efficiency, low cost, small gas turbine engines, for military and civil power generation and propulsion systems*
  - *Simple Brayton Cycle systems from 350 kW to 2,250 kW in size*
  - *Specific fuel consumption 20-35% better than state of the art small turbine engines (<1,000 kW size) and competitive with similar size diesels*
  - *Microturbine systems, recuperated and simple cycle, from 10 kW up to 350 kW*
- **Current DOE Projects:** *Phase II SBIR program, started September 2011, to design and test critical components for an advanced technology, high efficiency, low cost gas turbine powered genset*
  - *Simple cycle system with a Rankine “Bottoming Cycle” steam system to recover exhaust waste energy*
  - *Turbine shaft direct drive, high speed generators*
  - *Capable of producing 1,500 kW*
  - *High thermal efficiency goal set at 50%*
- **Current DOD Projects:** *Navy (NSWC-CD) Phase I SBIR program to define a main gas turbine exhaust waste heat recovery system, started March 2011*

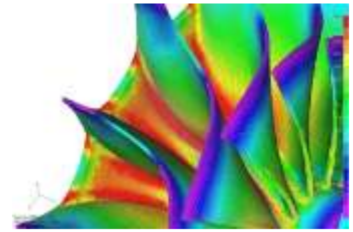
Using available and proven technology – no inventions required

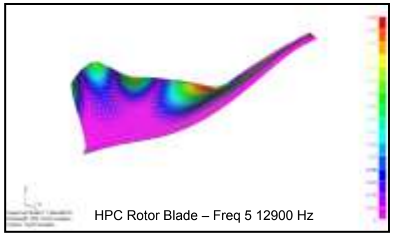
Candent Technologies Technical Capability



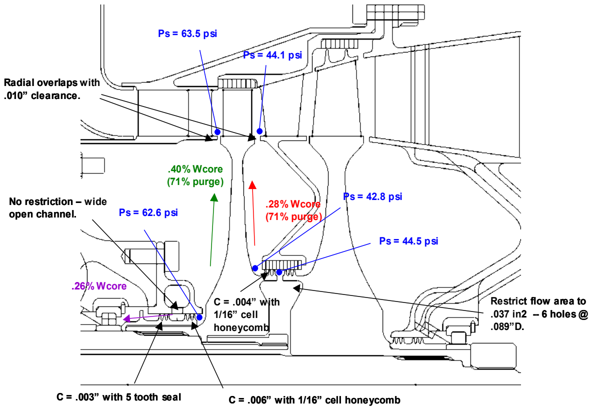


Gas Turbine Performance, PD, Detail Design and CAD Modeling Capability



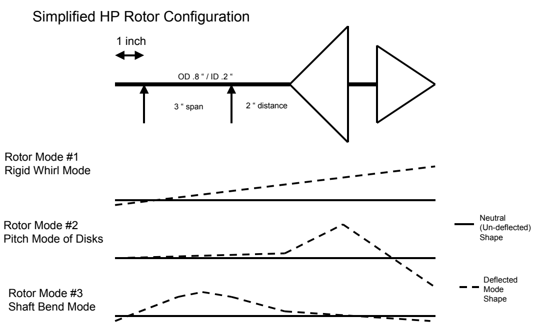


Static and Dynamic Structural Analysis



Secondary Flow and Heat Transfer

Aerodynamic Design and CFD Analysis



High Speed Shaft Dynamics

Sea Level Test Cell Facility

State of the art system and component design and analysis capabilities

High Power Density: The Gas Turbine Solution

Candent Technologies

Turbine Power Systems

Increased Deployment of Modern Warfare Systems Will Require More Power Generation Capability

- The sophistication of current and future weapon systems will continue to increase the requirements for electrical power
  - Individual Warfighter size
  - Tactical force size/land vehicle/tactical naval craft mounted
  - Base size/large vehicle/naval vessel
- While modern systems are more efficient, they are more numerous
- Logistics support for power generation systems is also increasing
  - Fuel Stocks Inventories
  - Transportation
  - Maintenance
- Power generation design continuously driven to
  - Higher Power density
  - Improved Mobility
  - Higher Efficiency
  - Higher Reliability
  - Improved Maintainability
  - Lower Cost

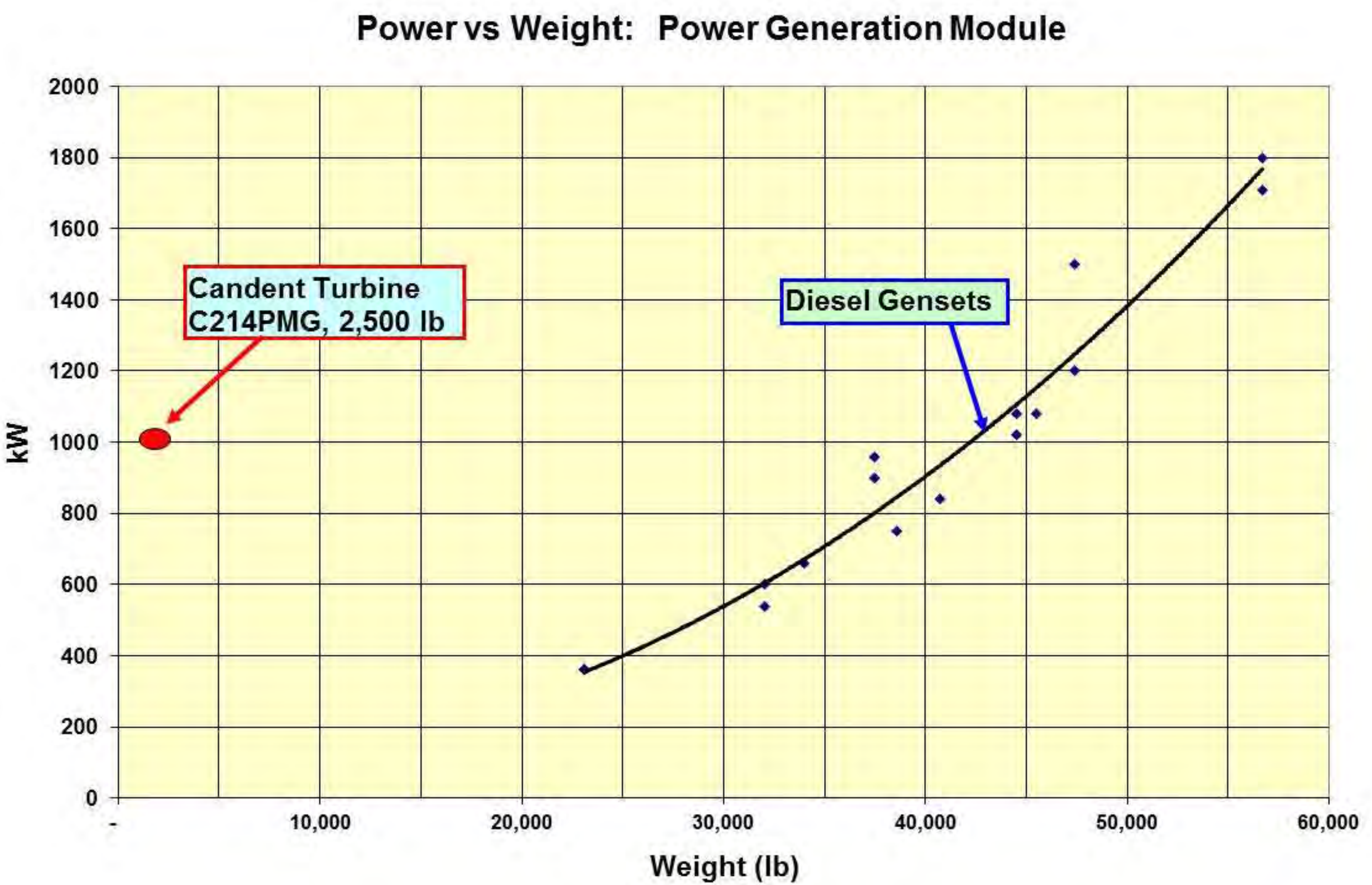
More high power density generation needed by deployed units

Turbines Provide Very High Power Density Efficiently and at Cost Effective Rates

- Gas turbine specific power is much higher than similarly power rated reciprocating engines
  - Lighter overall system weight by an order of magnitude
  - Smaller volume by factor of at least 4 to 5 vs. piston engine genset
- Candent advanced technology gas turbine has fuel efficiency comparable to diesels of same power
- High speed generators at turbine output shaft speed eliminate need for heavy gearboxes, minimize system complexity
- Multi-fuel capability of gas turbines easily allows great flexibility in use of available fuels, i.e. diesel, jet, kerosene, bio fuel, natural gas, propane, methane, etc.
- Gas turbine MTBO much longer than piston engine gensets, typically in excess of 20,000 hr
- Gas turbine has lower life cycle cost than comparable piston engine
  - Significantly less scheduled and unscheduled maintenance
  - Longer MTBO
  - Similar acquisition cost as diesels

Advanced Technology Gas Turbines Offer Viable Solution

Gas Turbine Power to Weight Advantage



Gas Turbine Large Mobile Power Genset

Candent Technologies

Turbine Power Systems

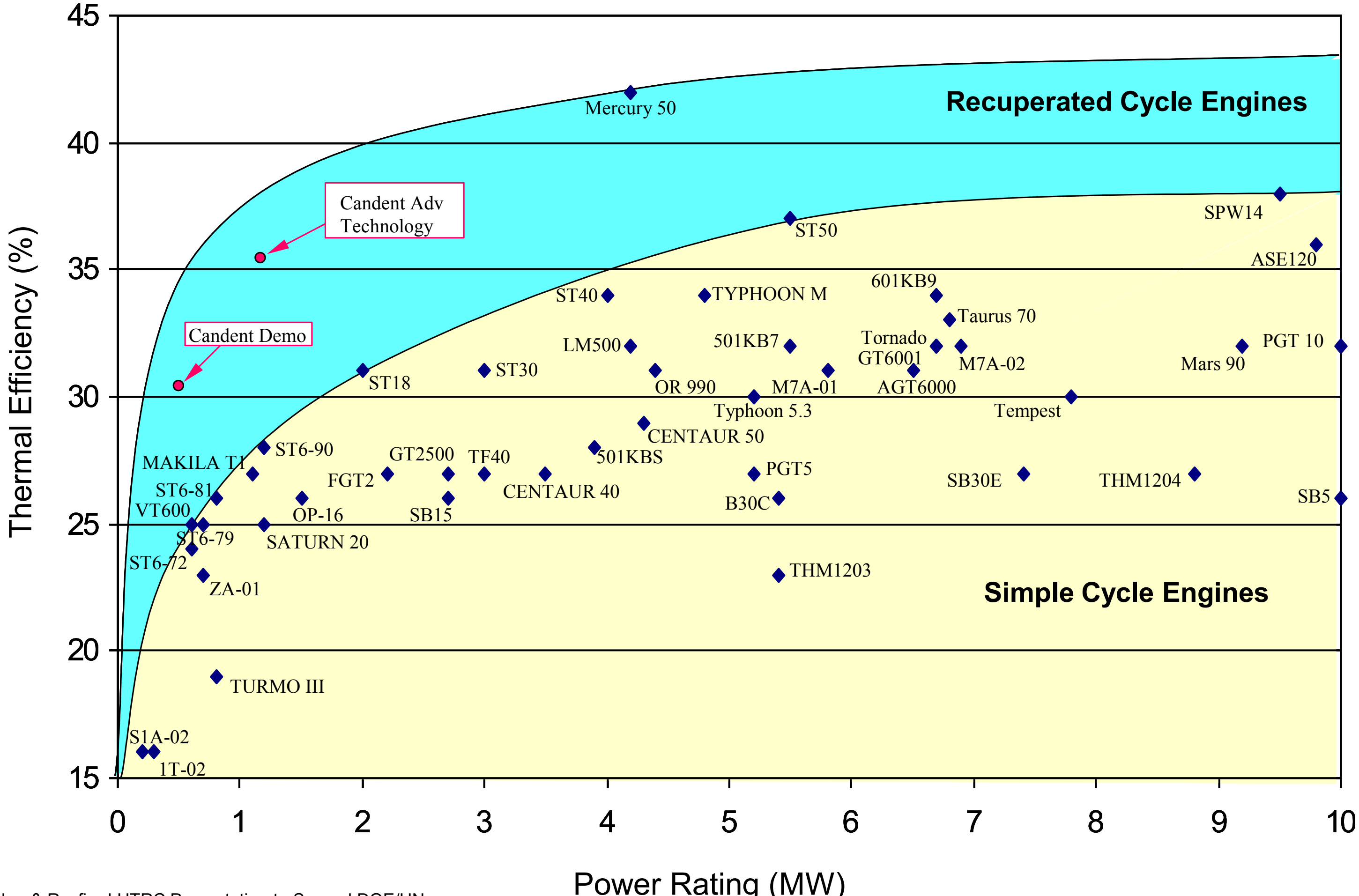
Candent Advanced Technology Impact

- Larger gensets, 350kW-2.0MW would also greatly benefit from Candent's advanced technology gas turbines
  - High pressure ratio provides higher efficiency
  - Fuel burn comparable to similar power rated diesels
  - Inherently more reliable
  - High power density minimizes weight and size, provides highly enhanced mobility
  - Longer MTBO than diesels, by at least 100%
  - Lower Scheduled and Unscheduled maintenance
- Candent is developing more efficient gas turbine under DoE sponsorship
  - Engine core testing scheduled for 1Q12
  - System thermal efficiency goal is 50%
- Larger gas turbines use state of the art technology hot section airfoil and cooling designs, achieve competitive fuel burn

Candent's advanced technology enables genset high power density with competitive fuel consumption and system costs

Candent Comparison versus Current Technology

Candent simple cycle engines have fuel consumption consistent with heavier recuperated engines

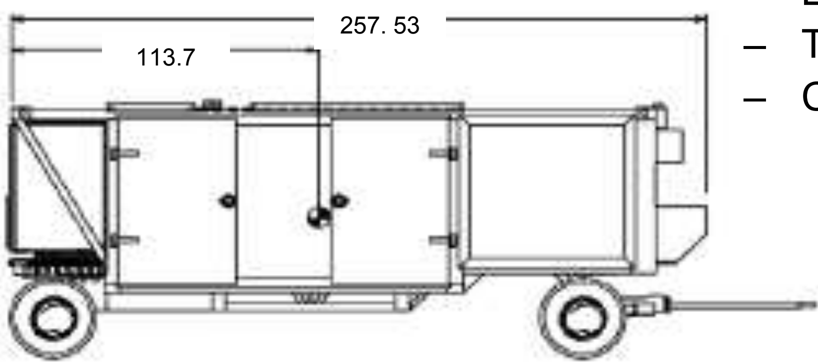


Data for graph from Sahm & Rosfjord UTRC Presentation to Second DOE/UN, *International Conference and Workshop on Hybrid Power Systems*, 17 April 2002

Higher Pressure Ratio Provides "Big Engine" Performance

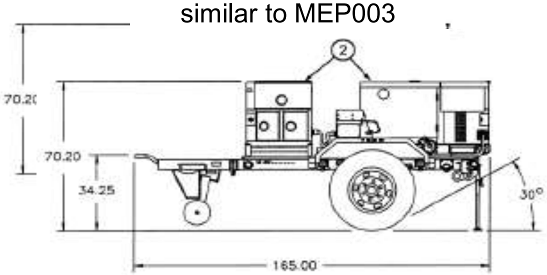
Large (900kW) Mobile Power Genset Application

Used in USAF Harvest Eagle and Harvest Falcon Bare Base Operating Kits



- Current Power Genset: MEP-PU-810A
  - Power 840 kW
  - Weight - 25,600 lbs
  - Length - 21.1 ft
  - Thermal Efficiency ~ 33%
  - C-130 Transportable

900 kW in a package similar to MEP003



- Candent Turbine Power System
  - Power 900 kW
  - Weight - 2,500 lbs (est.)
  - Length - 12 ft
  - Thermal Efficiency ~ 33%
  - Competitive first cost, lower LCC
  - Transportable in C-27, C-130, V-22, UH-47

Designed to be easily Mounted on 1-1/2 Ton Trailer, M103A3

Smaller, lighter, more easily transported system with same fuel consumption as diesel MEP- PU-810A

Microturbine Based Tactical Genset

Candent
Technologies
Turbine Power Systems

Microturbine Genset Solutions

- The standard military 30kW genset is the MEP 805/815
  - Diesel Powered
  - 30kW, 110 VAC, 60 Hz, 3 Phase
  - 88 cu ft
  - 3,000 lb
  - The MEP 815 is the 400 Hz version
- Candent has designed a microturbine genset to the requirements of the MEP805/815
  - Utilizes turbine hardware previously designed and tested under Army contract to Candent
  - Adds recuperator system to enhance efficiency
  - Uses high speed (turbine output shaft rpm) generator
  - Under 200 lbs (minus fuel tank) and 9 cu ft
  - Small and light enough to install in HMMWV, or MRAP
  - Small enough to install in tactical and SOC riverine or naval craft, 21 ft and up, including new vehicles such as CCM and USSV

Current systems are effective but are NOT high power density designs

20-40 kW Marine/Land Generator Specifications

Candent Technologies design is a microturbine based, 20-40 kW Advanced Marine/Land Generator system:

Generator Specifications

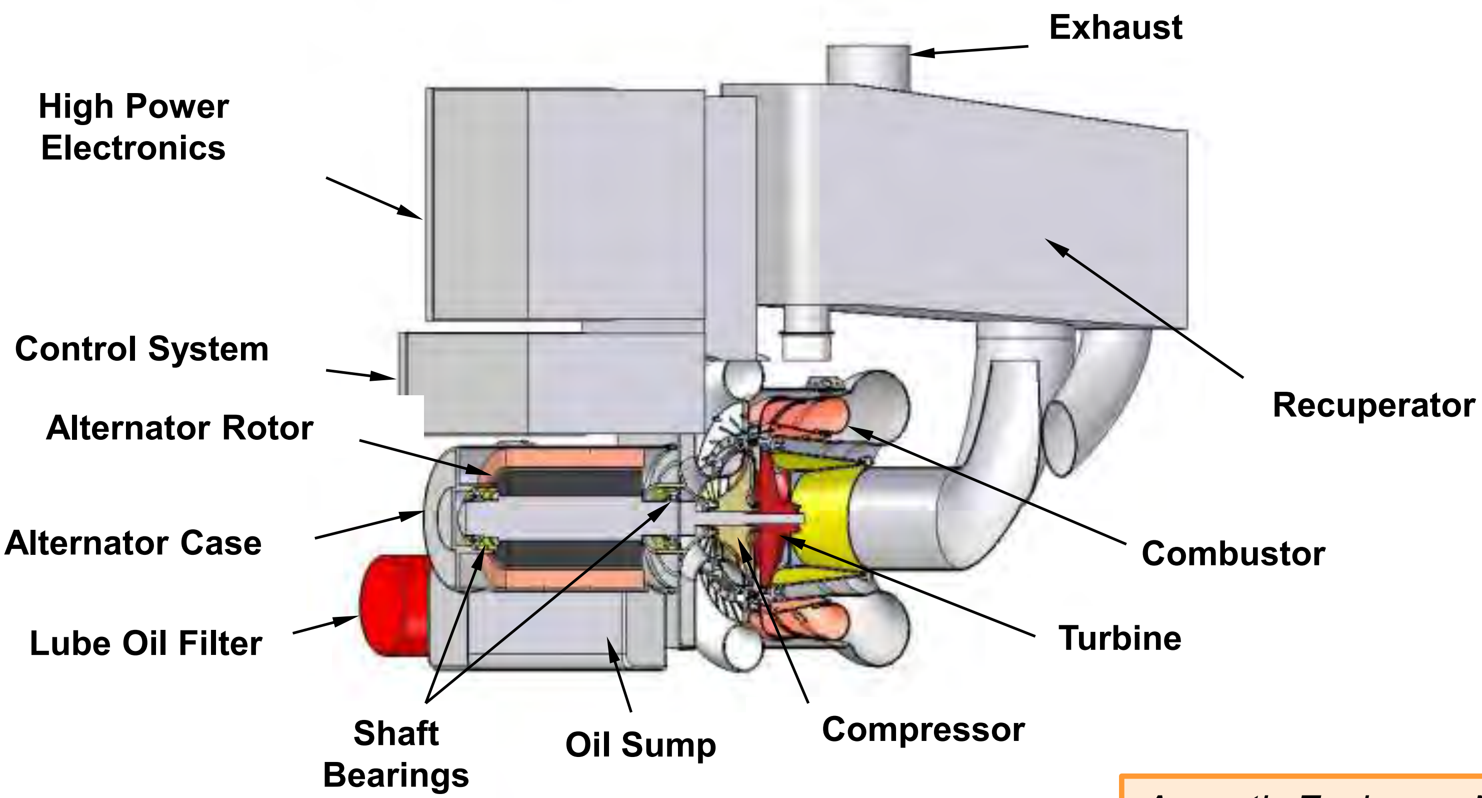
• Power Rating:	20-40 kW (50 kW de-rated to 40 kW)
• AC Power:	20-40 kW, 110/208 VAC, 3 Phase, 60 Hz
• DC Power:	Optional10 kW, 24 VDC, with 10-30 kW AC
• Speed:	75,000 rpm
• Shock Loads:	25g (40g peak)
• Materials:	Capable of surviving marine environment

Other:

The generator will also be used during the start mode for engine starting using a 24V battery.

A high speed generator means lower weight and volume

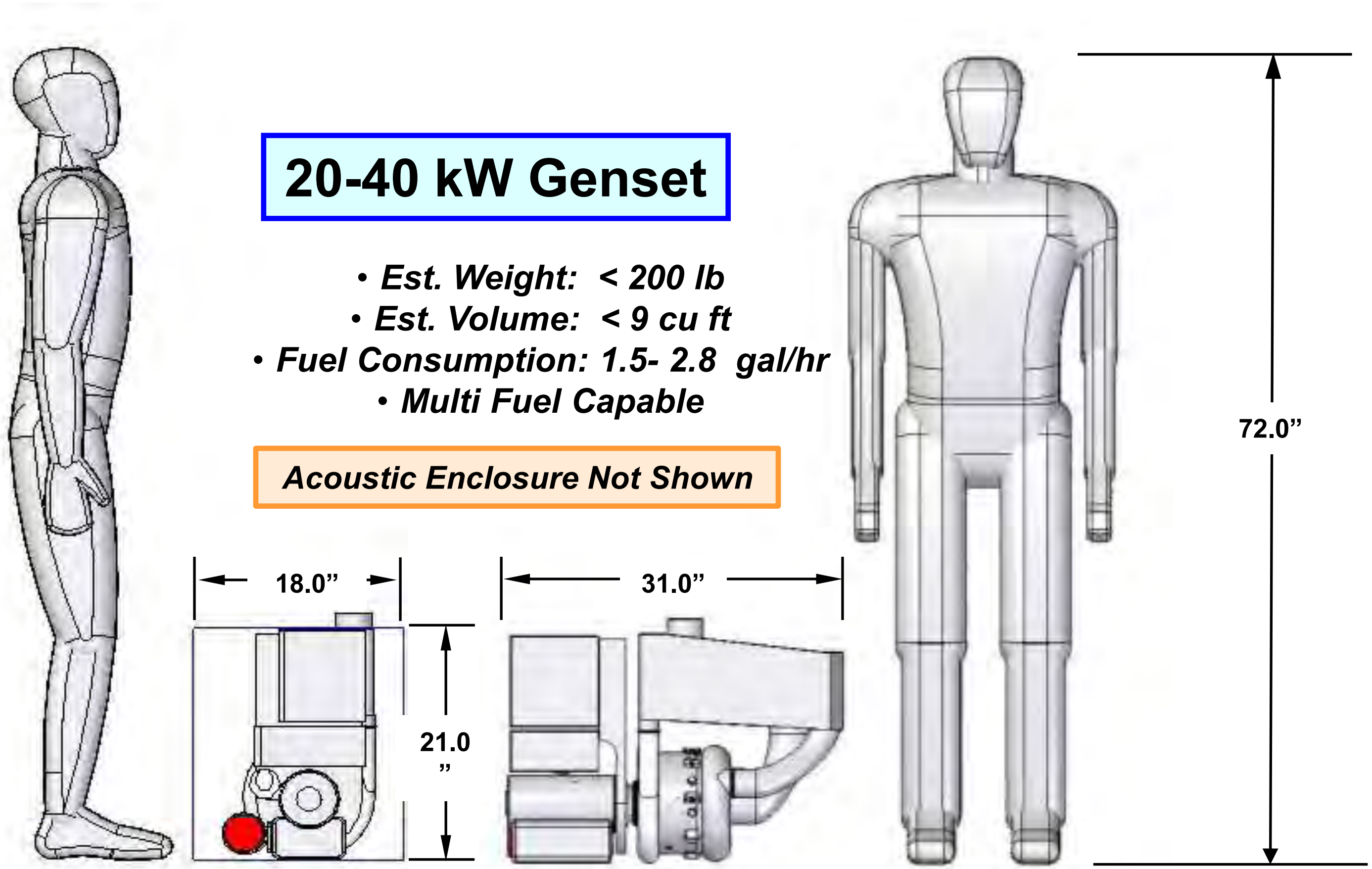
Microturbine Genset Components



Acoustic Enclosure Not Shown

Microturbines with recuperator and high speed generator provide highly efficient power in a very small package

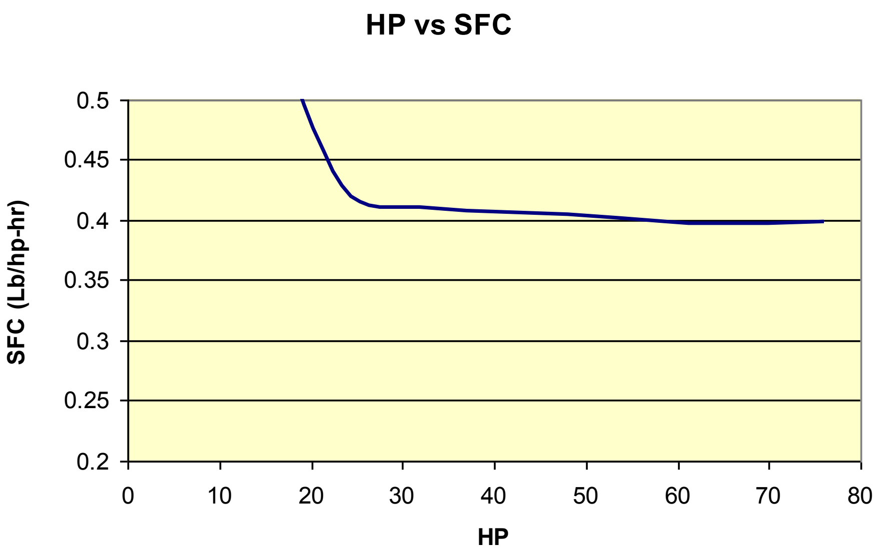
High Power Density 20-40 kW Microturbine Genset

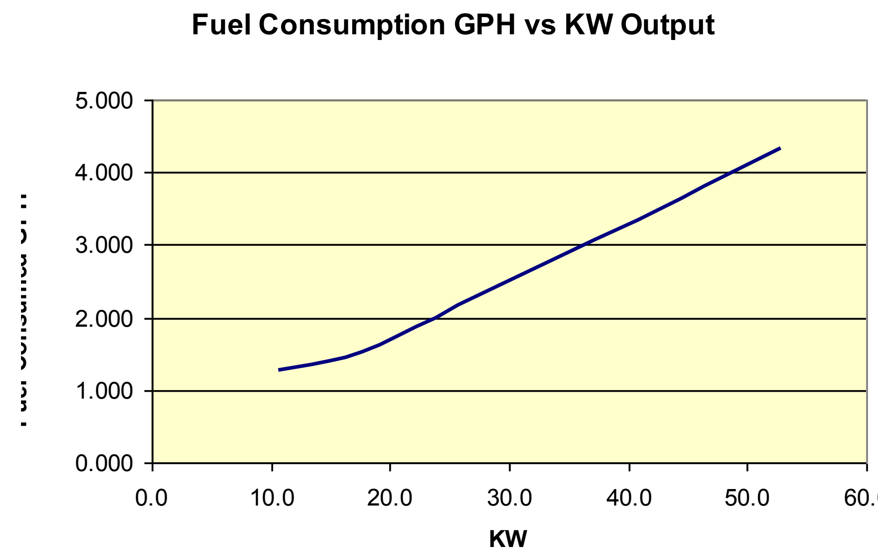


Estimated Dimensions

Compact and reliable power generation system

Fuel Consumption Same as Similar Size Diesel





- Flat SFC curve down to 30% power
  - Allows system to be oversized and have greater capability for minimal weight penalty
  - SFC and GPH are about the same as similar sized diesel
  - Power off-load capability of up to 40 kw even on a hot day

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Microturbine Genset Advantages

- Smaller, lighter more mobile power
  - At least 80% lighter than conventional diesel system
  - Smaller logistics transportation footprint
  - Transportable in more aircraft types, including smaller rotorcraft
- Rugged design
  - Capable of being used in high shock environment, i.e. off the road, or in high speed boats, or shocks due to explosive detonations in water or land
- High reliability and low maintenance
  - No oil change interval, top up as required
  - Long life, over 40,000 hrs.
  - Minimal on location maintenance
    - Air filter cleaning when prompted by system
- Fuel consumption on par with diesels of similar size
  - No increase in fuel logistics tail required for fuel stocks

High power density in a smaller, more mobile package

Summary and Conclusions

Candent Technologies

Turbine Power Systems

Summary and Conclusions

- ***Increased deployment of modern warfare systems will require more power generation capability in the field to support the Warfighter***
  – Candent's advanced turbine technology provides viable solutions
    - Lighter, smaller, highly mobile systems
    - Multi-fuel capable systems provide high flexibility
    - Cost effective and competitive
- ***Technology is applicable to microturbine sizes from 20kW to 350kW, and in larger sizes up to 2.25MW***
- ***Physical size enables installation in :***
  – Small land vehicles such as the HMMWV or the MRAP
  – Small boats such as the 11m RIB / CCM, SOC-R, USV, or Mark V / CCH types, or similar sizes
  – Large naval vessels
- ***Candent gas turbine technology is cost effective and competitive***
  – Acquisition costs competitive with similar power diesel systems
  – Turbine system Life Cycle Cost is lower due to longer TBO's and substantially lower scheduled and unscheduled maintenance costs
  – Turbine system substantially enhances maintainability, supportability and readiness

Gas turbine based gensets offer viable, highly reliable, highly mobile, cost effective high power density solutions

Contact Information

Candent Technologies

Turbine Power Systems

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Man-Portable Tactical Power

Report on Efforts

A Presentation Prepared for

NDIA 2011 Joint Service Power Expo

May 2 – 5, 2011

Myrtle Beach Convention Center, Myrtle Beach, SC

by

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4 Armstrong Road, Shelton, CT 06484
Ph : 203 925 7630 x 101; Mobile : 203 915 3166
Fx : 203 925 7631; em : SPaulDev@DStarEngineering.com

Outline

1. **Company Background**
   0.1 – 100 hp Heavy Fuel Engines, Turbine Engines, Hybrid Power Systems

2. **Need for Portable Power Solutions :** Light-Weight Heavy-Fuel Gen-Sets
   Example : ONR Goals for a 500 W – 1000 W Power System

3. **Problems with Conventional Generator Sets**
   Size, Weight, Noise, Wet-Stacking
   Challenges in Developing Small, Heavy Fuel Engines

4. **Light-Weight Power Solutions by D-STAR Engineering**
   Strategies for Developing Light-Weight Heavy-Fuel Engines
   Examples of D-STAR Heavy Fuel Power Systems
   Business and Teaming Strategies (Beneficial to the Government and Others)

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   Technologies have been Developed and Validated
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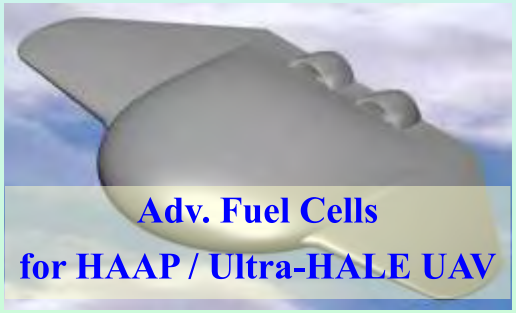
D-STAR Engineering Experience Base

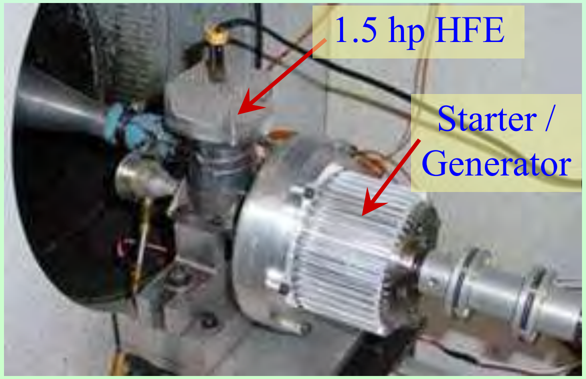
0.1 – 100 hp Heavy Fuel Engines, Turbine Engines, Hybrid Power Systems

6 hp Class 4-stroke M-COTS HFE



Mini-FADEC for 1.5 hp HFE

Miniature Turbine Engine



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ONR BAA 06-023 : Original Goals and D-STAR Prototype Capabilities

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ONR BAA 06-023 2

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9) Be able to operate from a remote standard 5 gallon military fuel container with the capability to pump fuel from that container : **Yes.**

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12) Be able to **operate in a range of battlefield environments** (i.e., salt water atmosphere, diesel fumes, dust) : **TBD**

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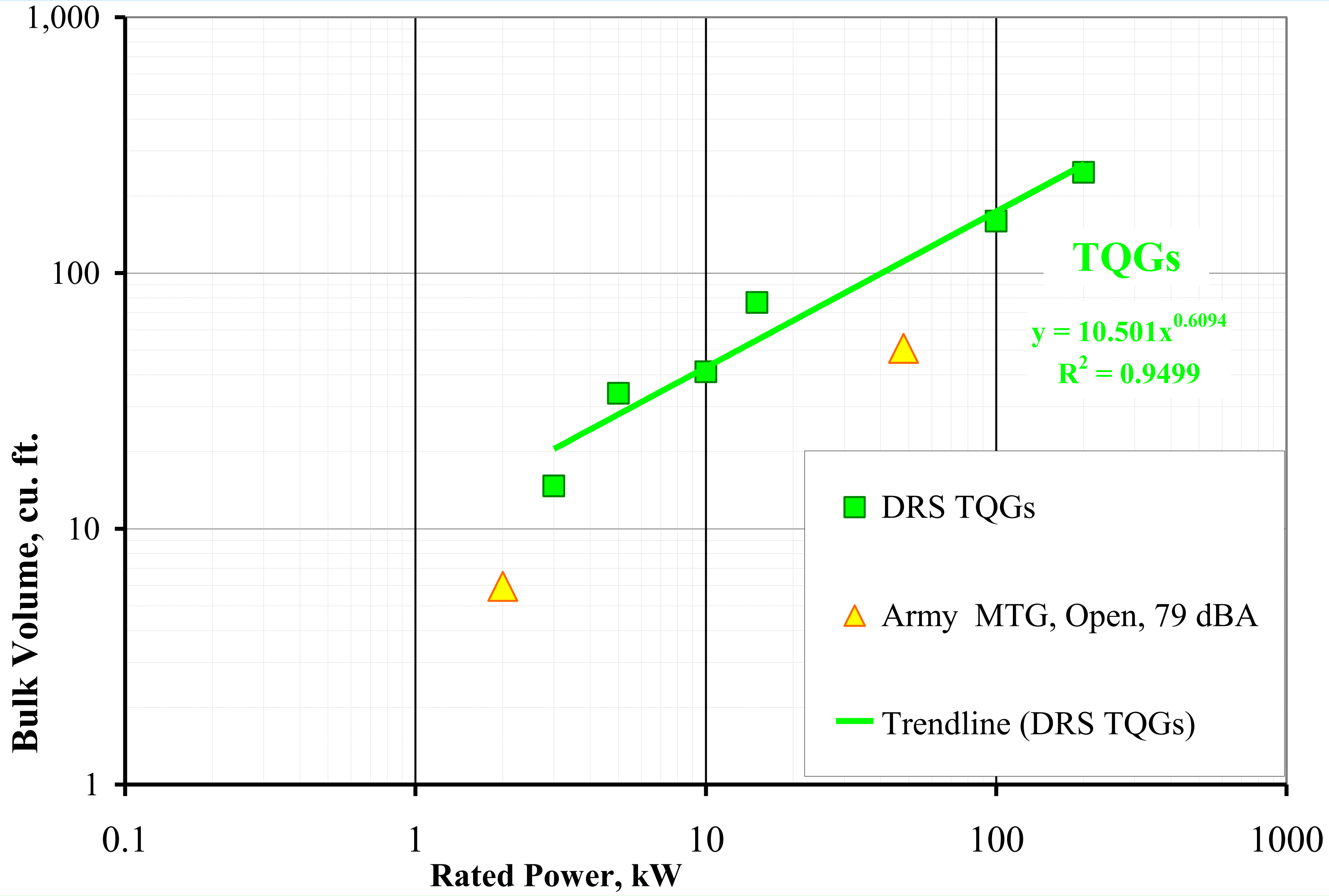
Problems with Conventional Generator Sets

Size : Military Generator Sets are Too Large



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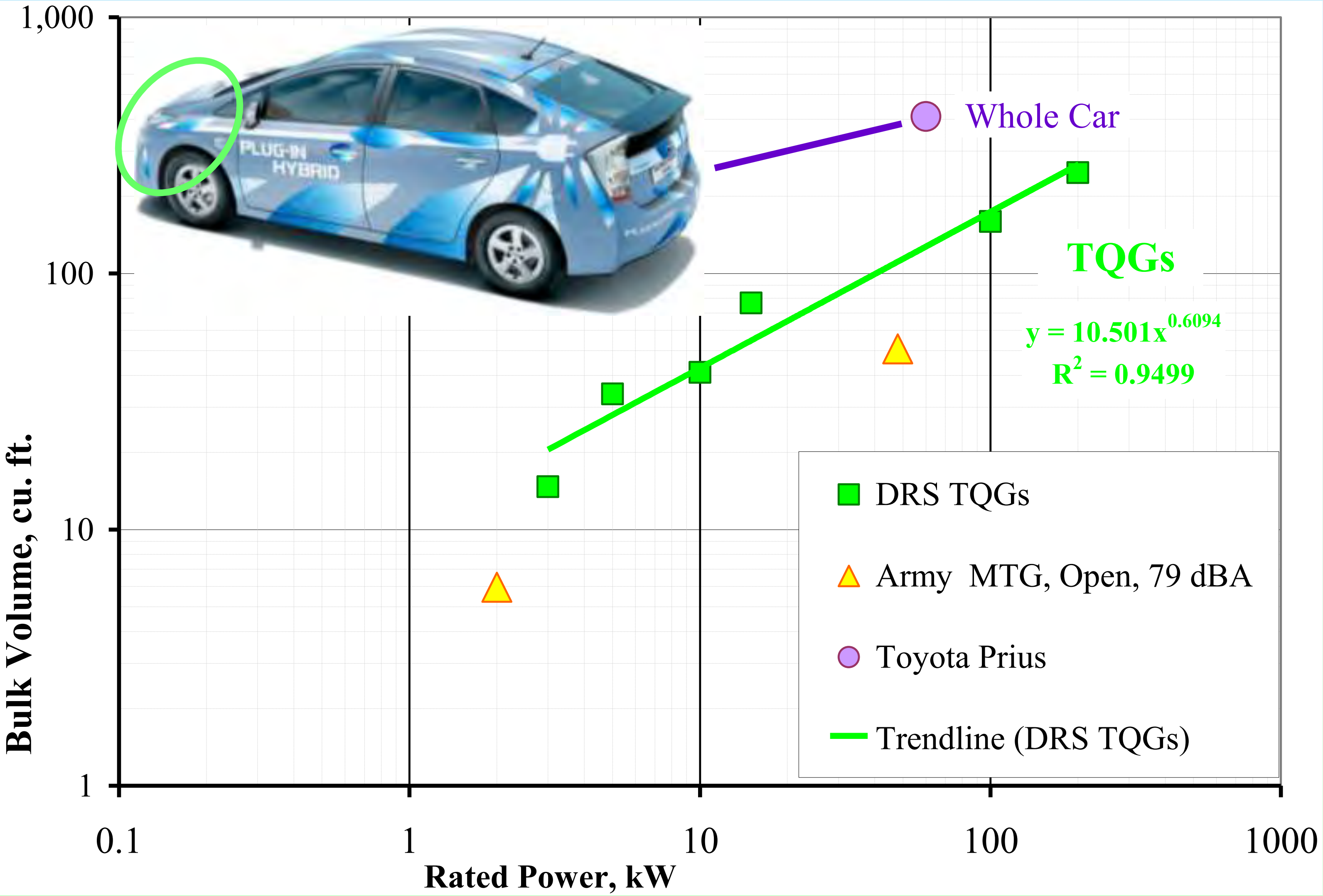

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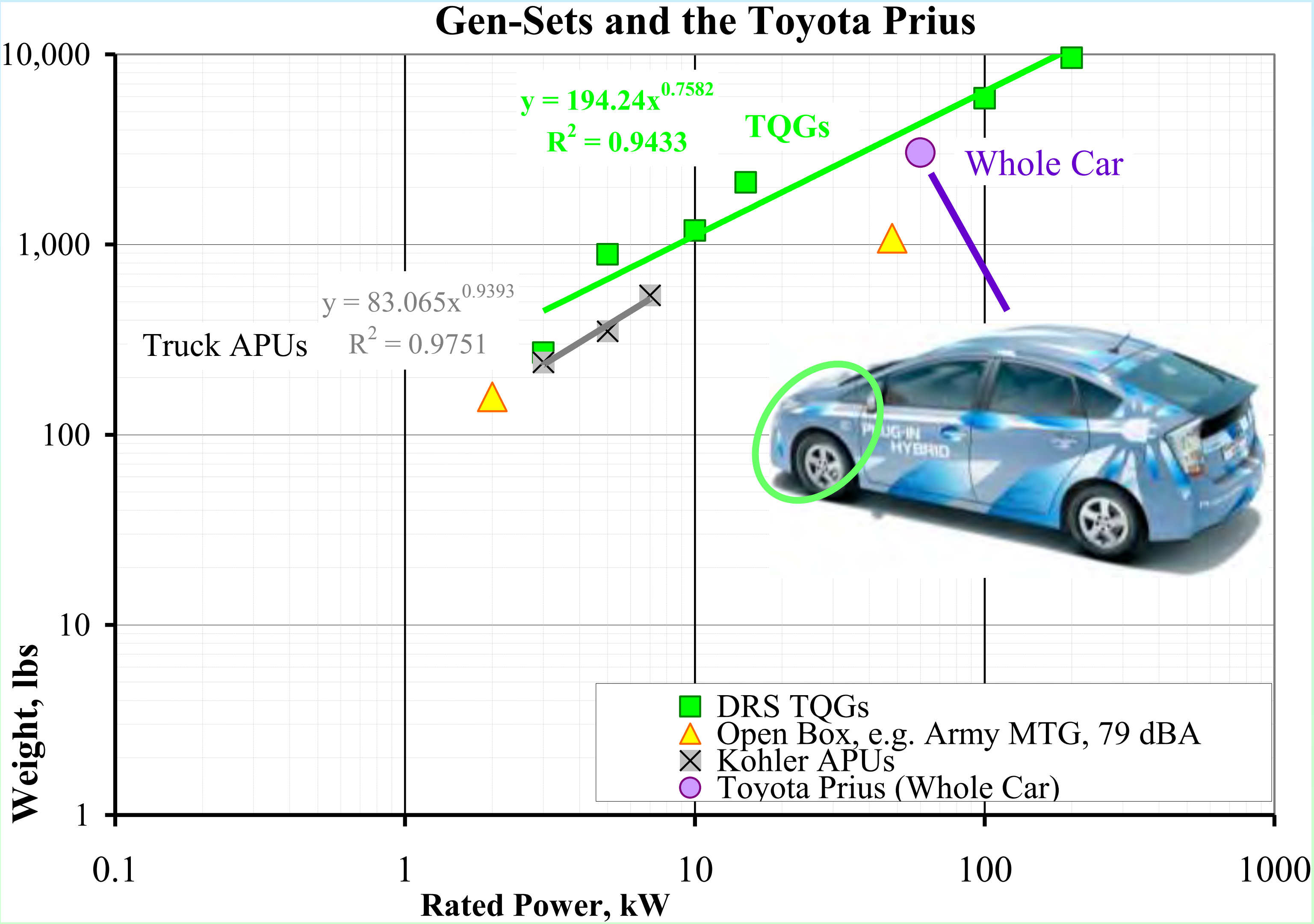

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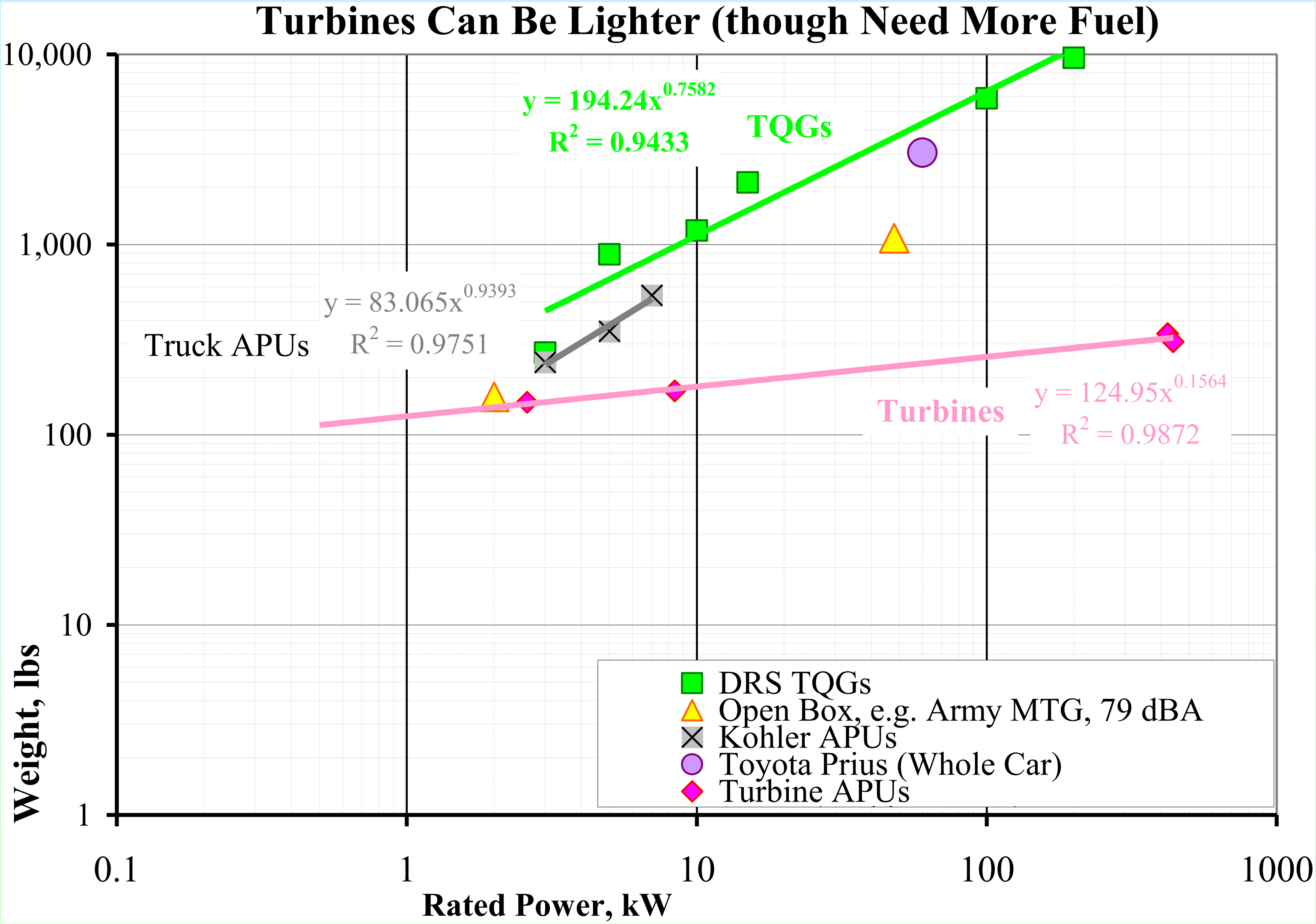

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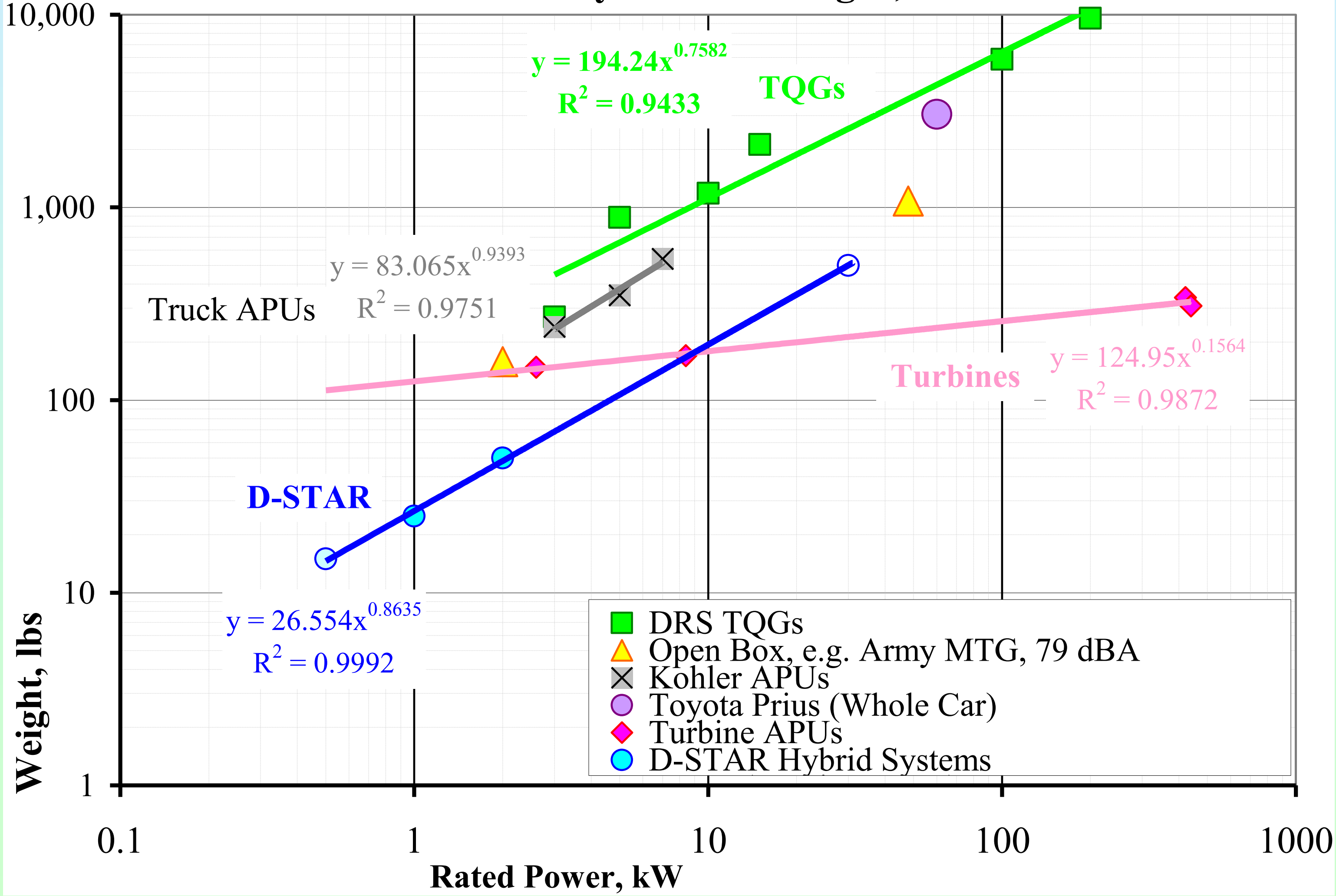
D-STAR Power Systems are Light, Fuel Efficient



Problems with Conventional Generator Sets

Noise : The Enemy of Stealth and Military Success.

The 2 kW MTG Makes 79 dB at 7 m

TQGs Achieve 70 dB, but are 2x Heavier (per kW) than MTG.

Wet Stacking : Maintenance Problems with Exhaust Systems.

Can be Avoided by Variable Speed Operation.

Key Handicaps of Conventional Diesel Generator Sets and APUs

Large Size : Large, Low Speed Engine, Large Generator

Heavy Weight : Large Diesel Engine

Low Speed

Low Air Utilization, Low BMEP

Heavy Construction

High Peak Combustion Pressures

High Cost : Large Size & Weight, Greater Cost

High Noise : Combustion Shock Noise

Low Frequency Noise Difficult to Attenuate.

Exhaust Emissions : Stratified Charge Produces Smoke

High Peak Combustion Temperature Produces NOx.

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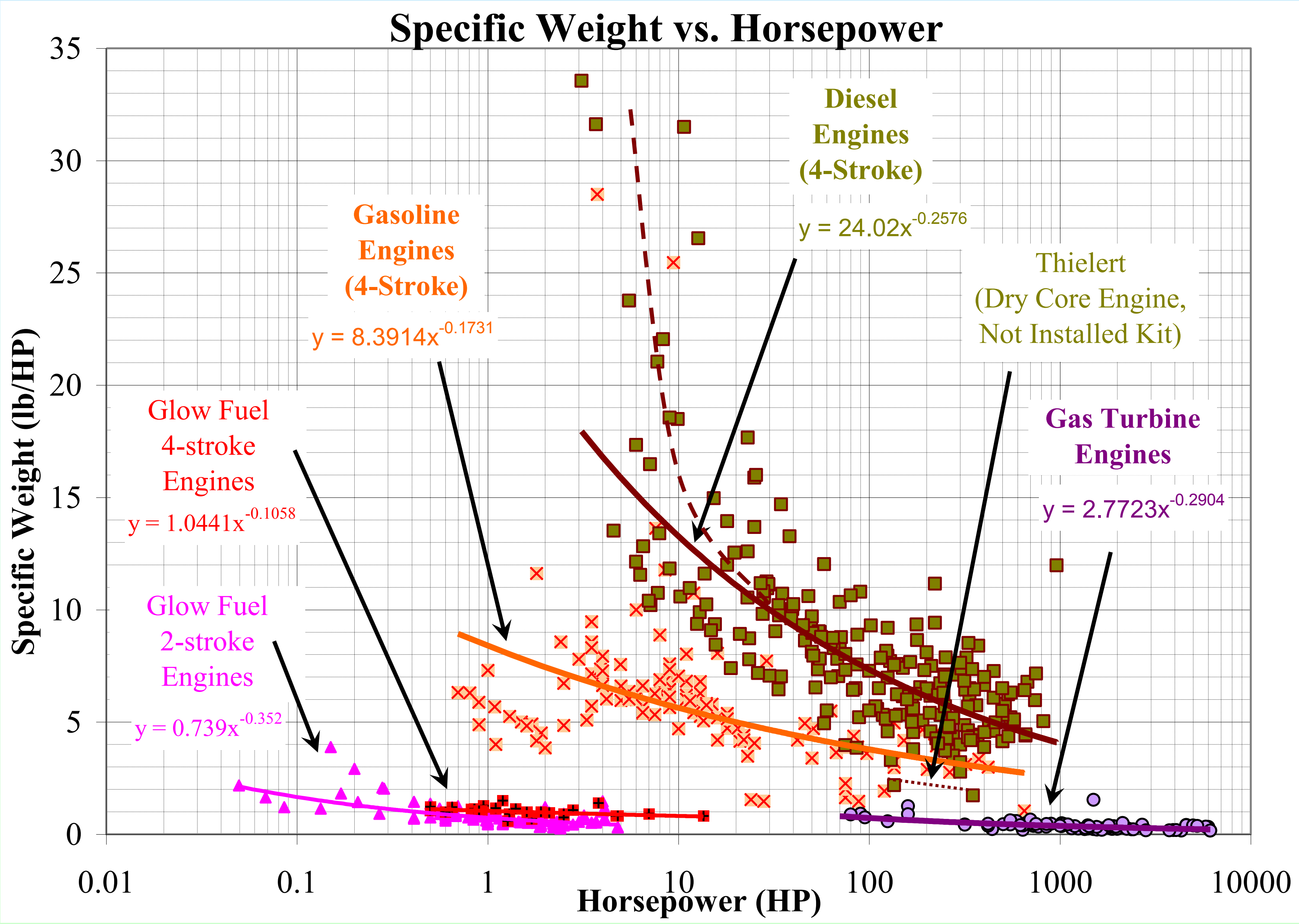
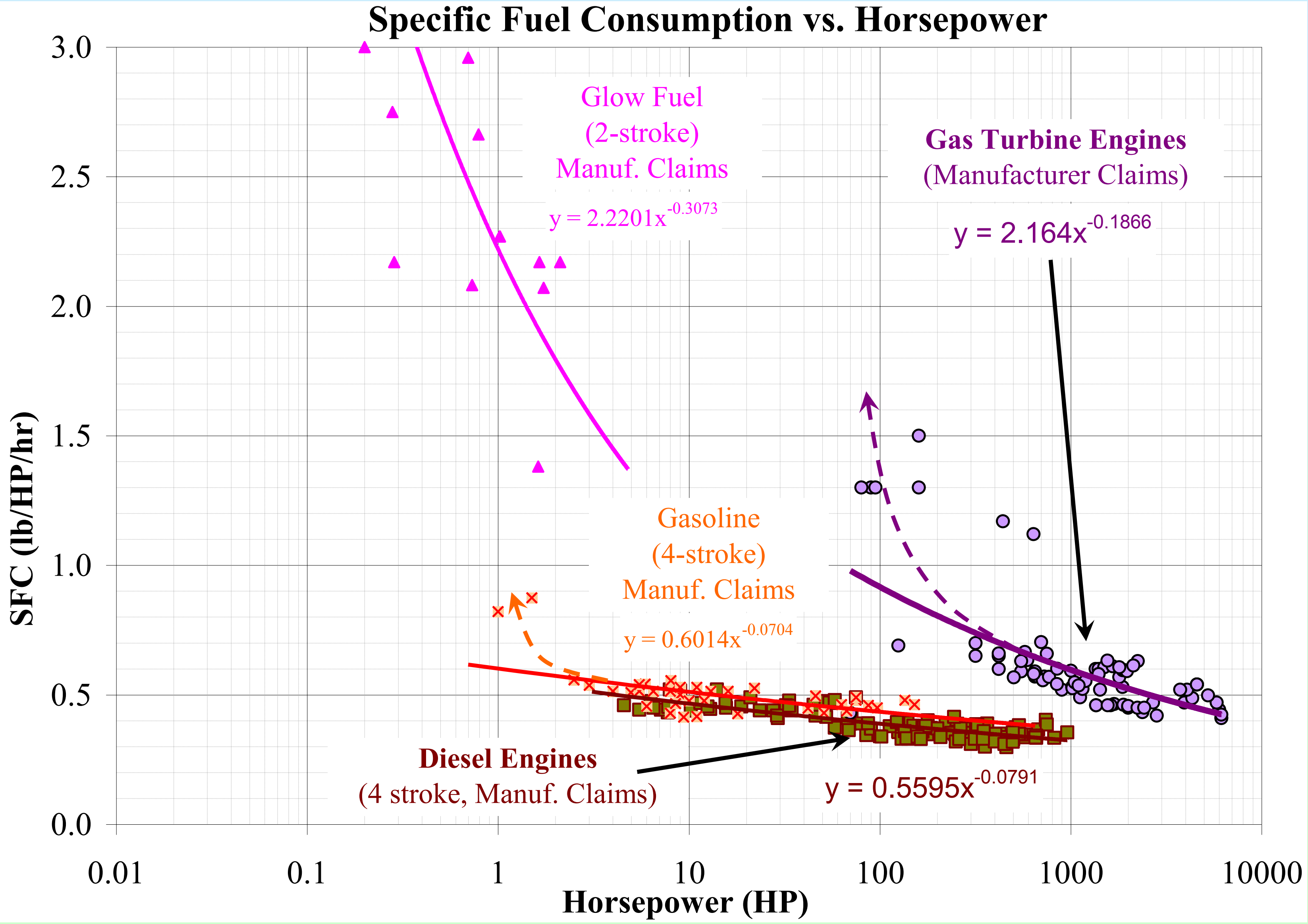
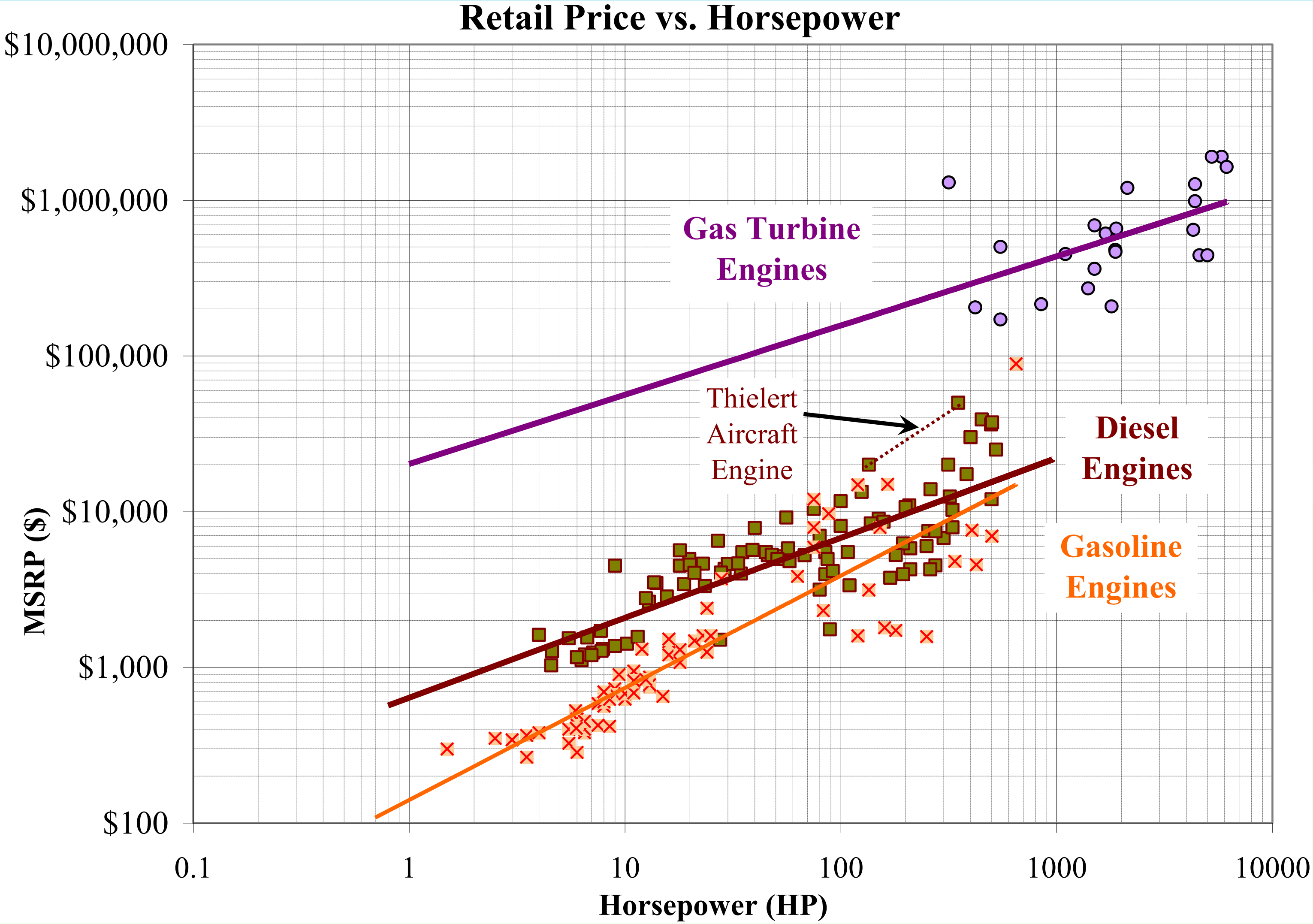
Handicaps of Conventional Heavy Fuel Engines : Weight



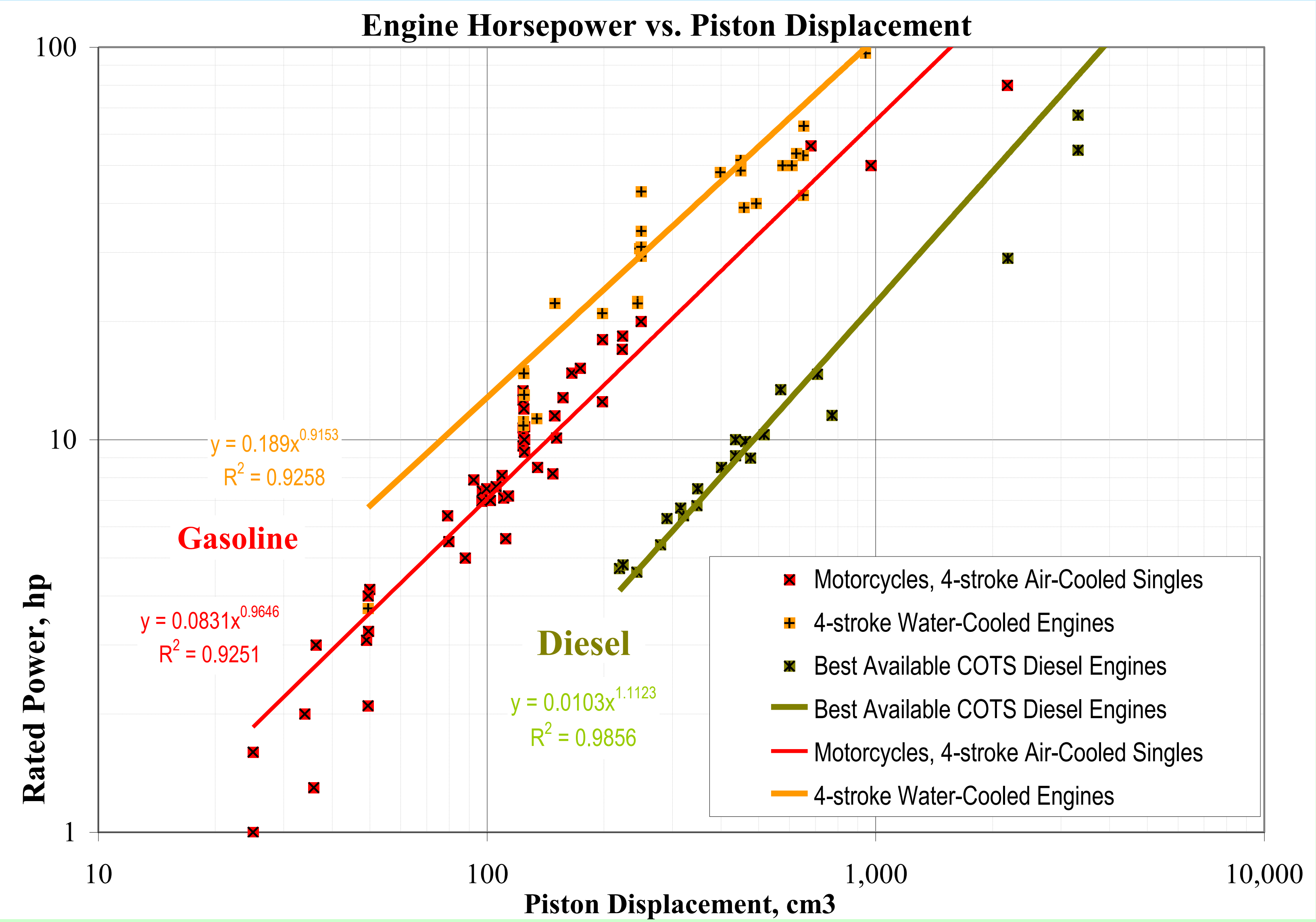
Turbine Engines Weigh Less, but Small Turbines have Excess Fuel Use



Heavy Fuel Engines are 2x – 3x More Expensive Than Gasoline Engines
Turbines are 10x – 20 x More Expensive than Diesel Engines

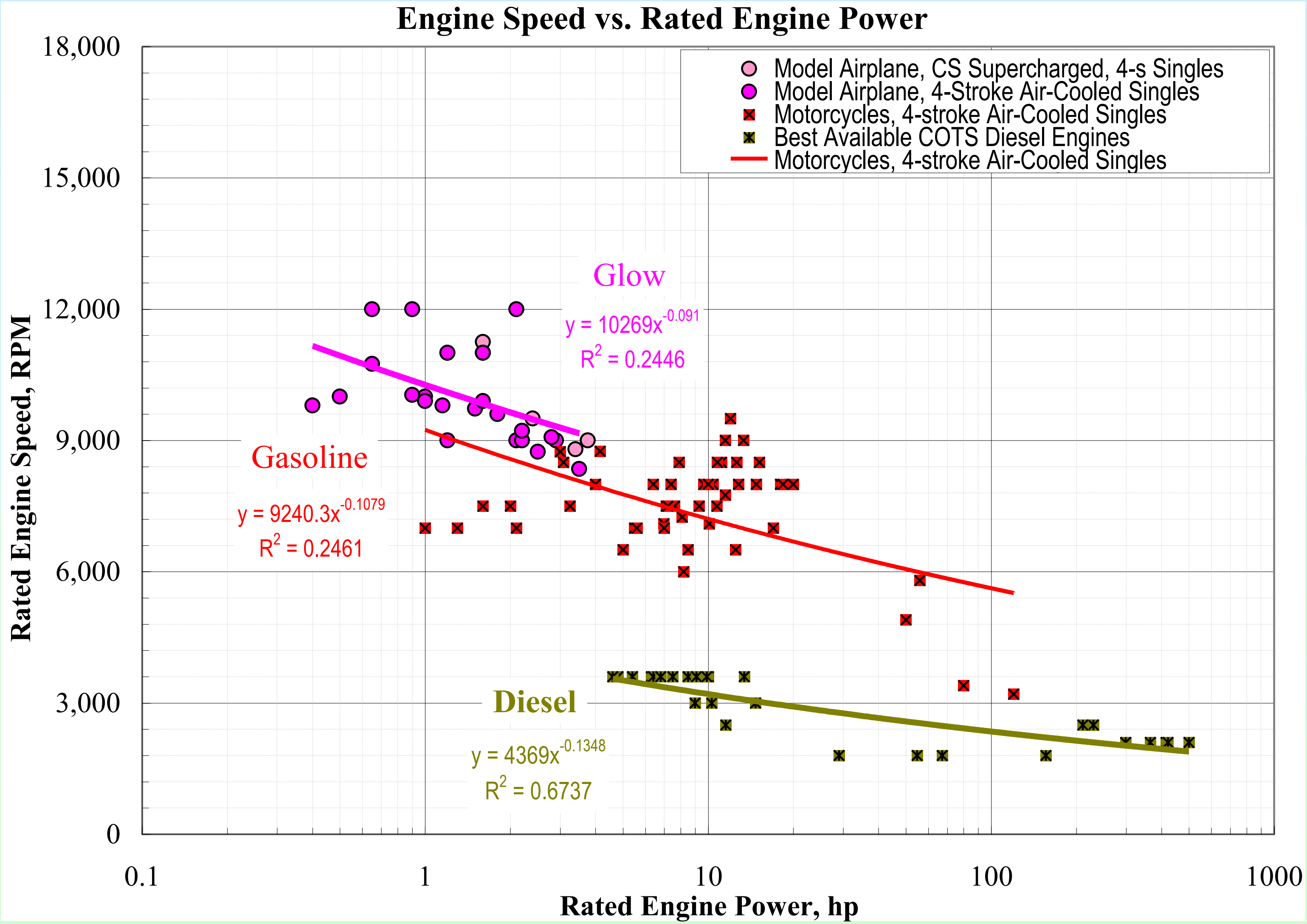


Heavy Fuel Engines Need to be 5x Larger Than Gasoline Engines



Why Do Heavy Fuel Engines Need to Be Larger than Gasoline Engines?

Low Speed and Low Air Utilization



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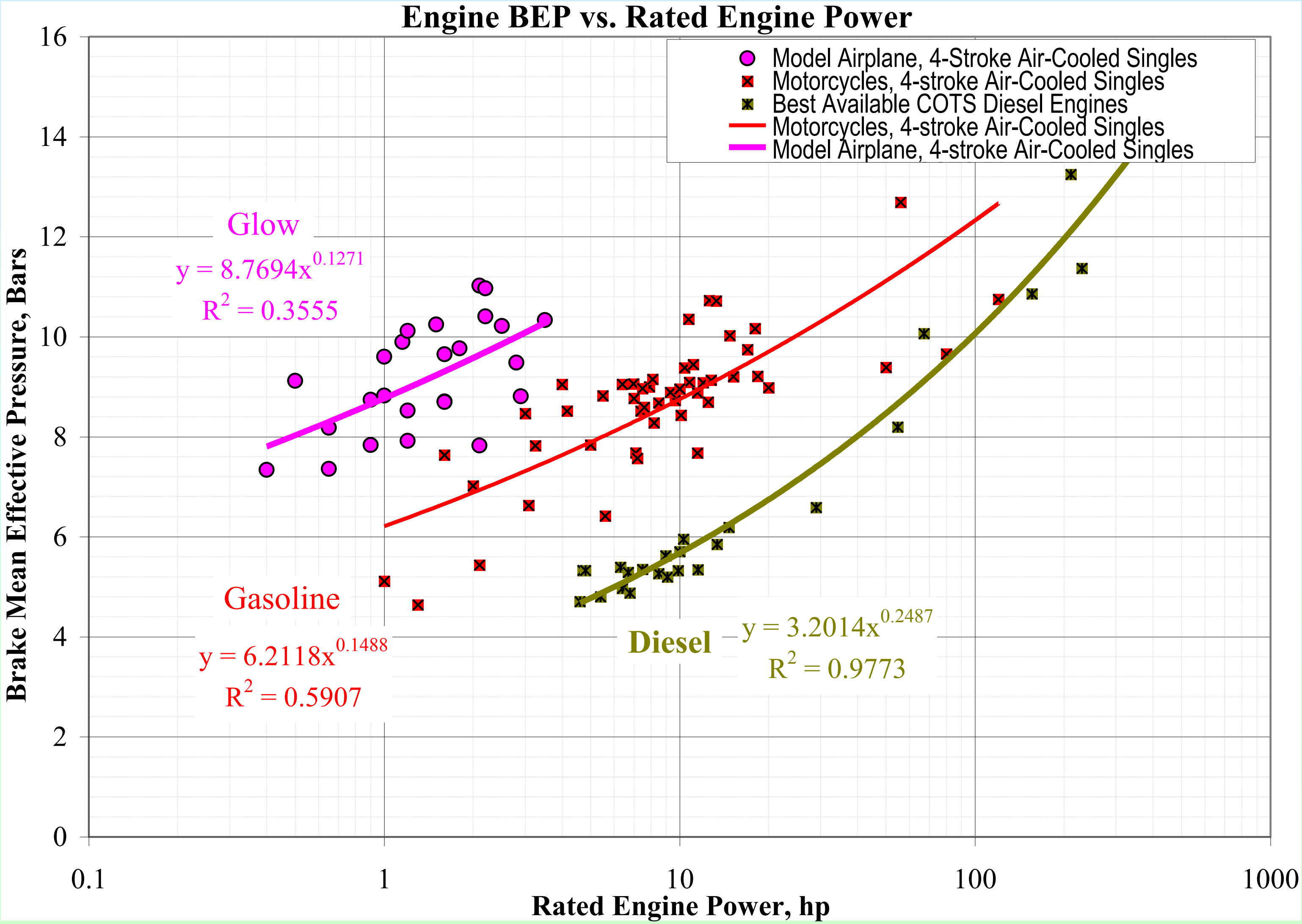
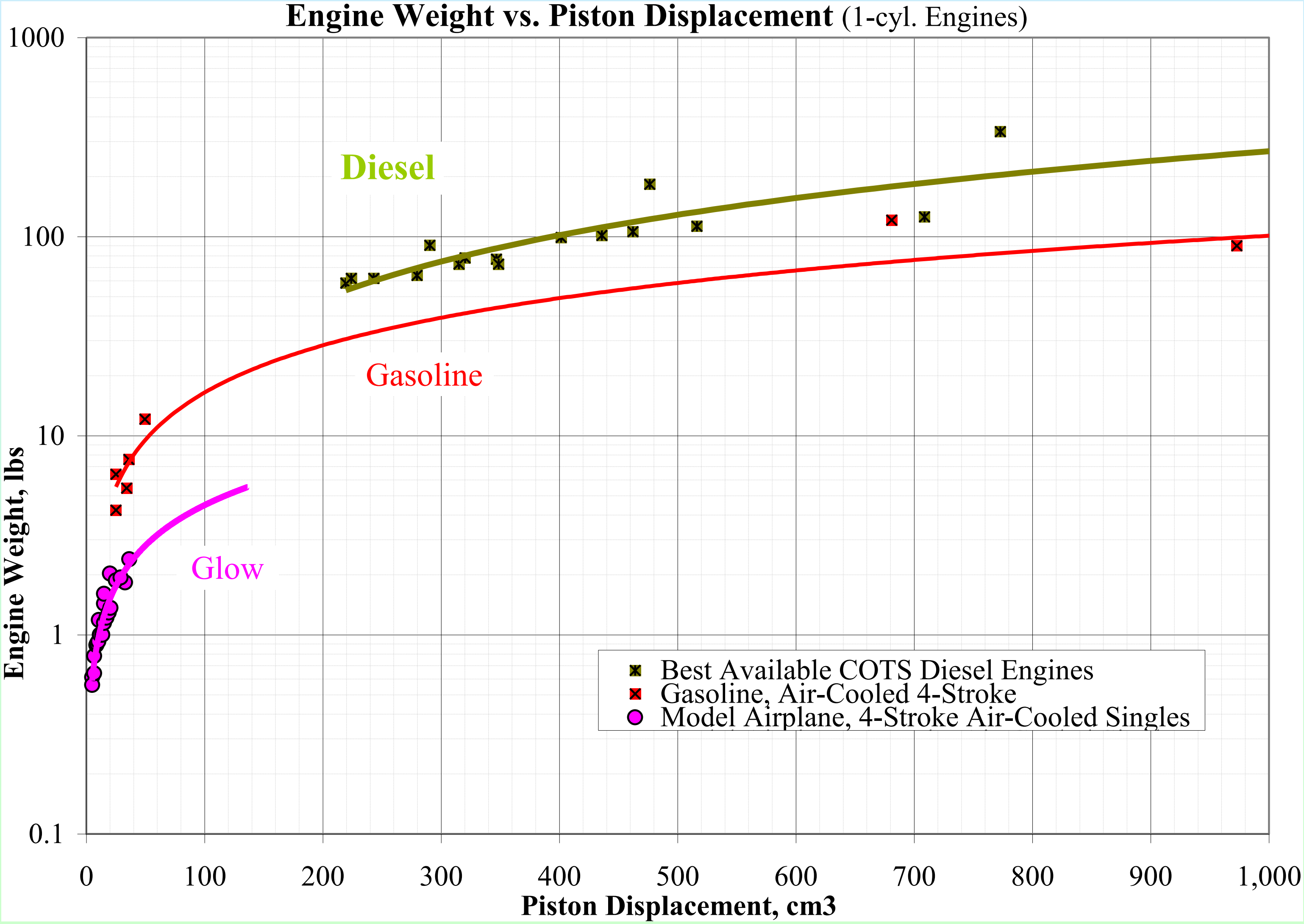


Even at Equal Size, Diesel Engines Weigh More
Because of High Compression Ratios, Very High Peak Pressures.



So, Diesel Engines are Large and Heavy Because of Low Speed, Low Air Utilization, High Peak Pressures.

What Can Most Improve Heavy Fuel Engines?
Lower End (Mechanism) or Upper End (Combustion)?

Piston-Rod-Crank System is

- ✓ 95% Efficient, Very Light Weight
- ✓ Has 100-year History, $100 Billion R&D Investment
- ✓ Sealing, Lubrication and Heat Transfer Problems are Well Understood, Solved.

'Barrel' Engines, 'Butterfly' Engines, 'Cat-and-Mouse' Engines (real names) ...

- ✘ Are Not More Efficient, Not Much Lighter
- ✘ Have Large Challenges of Sealing, Lubrication and Heat Transfer.

Improving the Upper End (Combustion) Can Enable

- ✓ Faster Operating Speeds for Higher Power Density
- ✓ Greater Air Utilization (BMEP) for Greater Power, Greater Efficiency.
- ✓ Reduced Peak Pressures for Lighter Weight, Lower Friction.

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D-STAR Strategies for Developing Light-Weight Heavy-Fuel Engines

1. **Enable High Speed Operation**, even with Heavy Fuels (e.g. JP-8)
   Conventional Diesel Engines Operate at < 3600 RPM
   D-STAR HFEs Operate at 6,000 – 18,000 RPM.

2. **Enable Full Air Utilization**
   Conventional Diesel Engines Operate at Phi < 0.6 (Smoke Limit)
   D-STAR HFEs Operate at Phi up to 1.0 (without Smoke).

3. **Enable Combustion at Low Pressures**
   Conventional Diesel Engines Operate at High CR, High Pmax.
   D-STAR HFEs Operate at Lower CR, Much Lower Pmax

4. **Ensure Active Optimization** of Engine Operating Parameters **(mini-FADEC)**

5. **Reduce Cost** Through Use of Gasoline Engine Components Where Feasible.
   Use Custom Components Where Needed.

Examples of D-STAR Heavy Fuel Power Systems

Current 2 kW Generator Set
Used by Army, Others
AC Only
158 lbs

D-STAR / Army 2 kW
✓ Power Core Demonstrated
50 lbs

D-STAR / ONR 1 kW
✓ Power Core Demonstrated
✓ Endurance Test Completed
✓ Prototype Delivered
✓ Performance Verified by Govt.

D-STAR / Army 500 W
✓ Phase 2 in Process
15 lbs

D-STAR / Army 300 W
✓ Selected for Phase 1

D-STAR / ONR / USMC 500 W – 1000 W

✓ **Power Core Demonstrated, ≅ 50 lbs. Demonstrated 1600W Cont., 1800 W Peak**

Potential

for

2+ kW

D-STAR / ONR 500 W – 1000 W

Phase 2.0 : Ended September ’09 : Technology Validation & Down-Selection

✓ **Heavy Fuel Engine Demonstrated, Technologies Down-Selected.**

Phase 2.1 : Nov. ’09 to Apr. ’10 : Demonstrate Power Cores, Endurance Ability

✓ **Power Core Built, Straight-JP8 to 1080 Watts DC Achieved (2 hours non-stop)**

Phase 2.2 : July ’10 to Jan. ’11 : Build Laboratory Prototypes of Generator Set

✓ **Endurance Testing (100+ Hours) Successfully Completed (> 700 Watts Avg.)**

✓ **Fully Integrated Desktop Unit Built and Tested, with All Systems Operational**

✓ **First Prototype Delivered, Successfully Tested by the Government.**

Phase 3 :   Support Testing of Prototype + In-House Testing

Phase 4 :   EMD / SDD

Engineering & Manufacturing Development / System Development & Demonstrations

✓ Endurance Test Done, ✓ Prototype Delivered, ✓ Performance Verified by Govt.

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ONR BAA 06-023

II. AWARD INFORMATION [As Planned]

Anticipated Award Information is as follows:

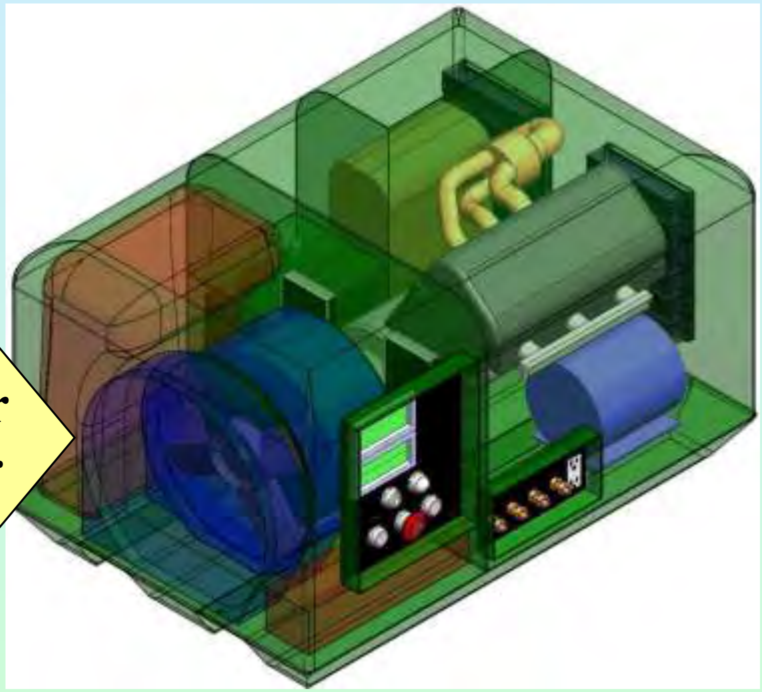
Total Amount of Funding Available for the Program: $16.5M over 4 years

Total Amount of Funding Available for each Award:

Phase 1 (Base) :	$200-300K	**Successfully Completed**
Phase 2 (Option 1) :	Up to $3M	**On-Time, On-Budget**
Phase 3 (Option 2) :	Up to $200K	**Teaming**
Phase 4 (Option 3) :	Up to $4.5M	**Under Consideration**

30 kW Heavy Fuel Power System : Conventional vs. D-STAR Technology

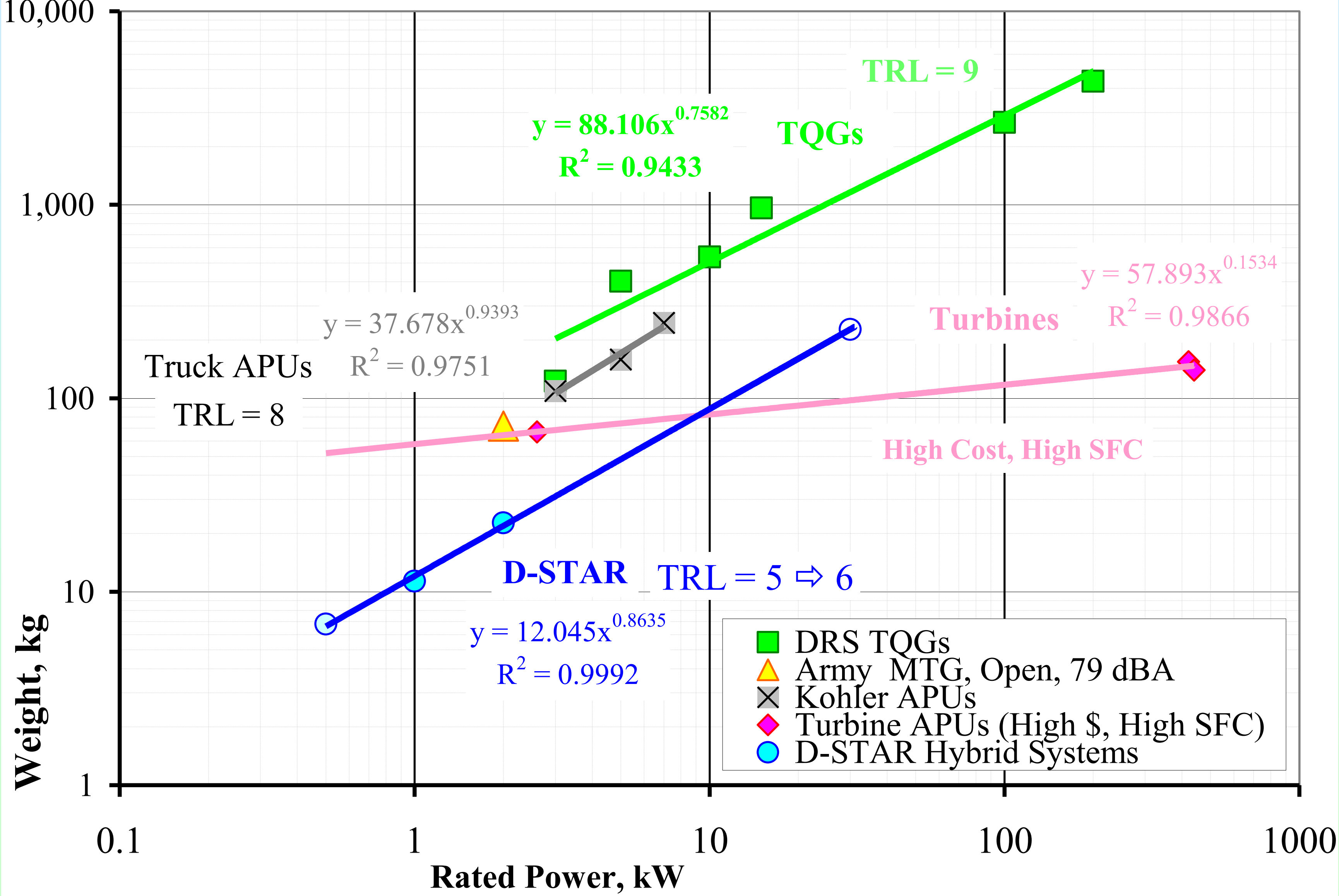
6 x Smaller
6 x Lighter



In-service 30 kW Gen-Set
80” L x 36” W x 55” H
3015 lbs basic
70 dB(A) @ 7m

Future 30 kW Gen-Set
by D-STAR Team
42” L x 28” W x 24” H
≅ **500 lbs** basic
67 dB(A) @ 7m

TQGs, Kohler APUs and D-STAR Power Systems



D-STAR Business and Teaming Strategies

Open to Teaming with Any and All ‘Good’ Candidates.

Potential Team Mate Must Bring Value Added to the Table.

The Goal is to Maximize Benefits

for All Three Stakeholders :

- **ONR / USMC / Government** (Large Cumulative Investment)
- **D-STAR Engineering** (twenty years of expertise and investment)
- **Potential Team Member** (for their Investment).

Outline

1. **Company Background**
   0.1 – 100 hp Heavy Fuel Engines, Turbine Engines, Hybrid Power Systems

2. **Need for Portable Power Solutions :** Light-Weight Heavy-Fuel Gen-Sets
   Example : ONR Goals for a 500 W – 1000 W Power System

3. **Problems with Conventional Generator Sets**
   Size, Weight, Noise, Wet-Stacking
   Challenges in Developing Small, Heavy Fuel Engines

4. **Light-Weight Power Solutions by D-STAR Engineering**
   Strategies for Developing Light-Weight Heavy-Fuel Engines
   Examples of D-STAR Heavy Fuel Power Systems
   Business and Teaming Strategies (Beneficial to the Government and Others)

5. **Conclusions**
   Technologies have been Developed and Validated
   TRL 5 Prototype Has Been Demonstrated, Delivered, Tested by the Govt.
   Teaming Opportunities are in Discussions, but are Currently Open

Portable Power Solutions

by

D-STAR Engineering Corporation

☆ **Extensive Prior Experience with Engines and Power Systems**

✓ **Delivered First Prototype for ONR 1 kW Portable Gen-Set, On Schedule, On Budget (BAA). Successfully Tested by the Government.**

✓ **Demonstrated 2 kW Power Core (limited by SBIR Funding)**

✓ **Developing a 2 hp HFE. Can be Basis of 0.5 kW, 15 lb Gen-Set**

✓ **Selected for a 300 – 500 Watt Hybrid Power System (10 lb Gen-Set)**

✓ **Designed a 30 kW, 500 lb Gen-Set.**

☆ **We Specialize in Light-Weight Heavy Fuel Power Solutions.**

D-STAR has Developed Key Enabling Technologies

for Lighter, More Portable Generator Sets / APUs that can

- **Use Diesel / JP-8 / Jet-A and Other Heavy Fuels**
- **Offer a Potential for Reduced Fuel Consumption**
- **Offer a Potential for Reduced and Cleaner Exhaust Emissions**
- **Offer a Potential for Cost Reduction.**

D-STAR Would Like to Team with a Larger Company

to Bring its Products to Market

Starting with the U.S., Expanding Globally.

Development of a lightweight, man-portable, heavy-fuel Generator

Les Gray, Andrew Pouring,
Scott Quigley, Nathan Longo

Customer Need

No heavy-fuel small gen set available (0.4-2kw)

Existing Solution = 2 Kw gen set

- "4-man portable"
- ~160 pounds
- Noisy
- Developed for "stationary" power

Need = Small, lightweight, portable, quiet

Competitive - $ per KW

Driving Forces – Small Gen Set

Single Fuel Forward –
- JP8 preferred
- Strong desire to use “scavenged fuel” in theater

Electronic Army –
- Battery charging a big issue

Fast and light –
- Single man portable

“Buy cheap” directive -
- Must be competitive on cost ($/KW)

Customers & funding emerging
- MEP (Mobile Electric Power)
- Nett Warrior
- USASOC

The Problem

1. Heavy fuels need “diesel process” to ignite
   - High compression ratios => high stresses
   - Units are heavy, and expensive – by definition
2. Spark Ignited heavy fuel – has been a “Holy Grail” for a long time
   - If possible – could adapt gasoline engines
   - Light, cheap, ubiquitous
   - Lots of experimenting – same problems keep arising
3. Heavy Fuels can be spark-ignited, if “hot enough”
   - Cold start not possible
   - Operation in cold conditions problematic
   - Some success – start on gasoline, switch after warm-up

Sponsorship

Mobile Electric Power (MEP) = Program to support development of spark-ignited heavy fuel technology

1. Initial work at QinetiQ – development of a “fog carburetor”
   - Developed for the Honda 1kw gen set
   - Voice of the customer on feature set and specifications

2. Additional work at Sonex – development of a “vaporizer”
   - Further development of a cold starting solution
   - Based on work for UAV 2-stroke heavy-fuel engines

3. **During development, QinetiQ and Sonex agreed on a Partnership, and work together to find an optimum solution !**
   - MEP supported the collaboration
   - QinetiQ contributed critical investment funds to keep the program going

Start with COTS

Honda 1 Kw gasoline gen set
- Quality
- Reliable
- High volume production
- Inexpensive

The Competing Solutions

1. First, solve the starting problem
   - Heat the fuel into a vapor electrically (from a battery)
   - Supply the hot vapor and air to the ignition chamber
   - Starts just fine

2. Switch away from electric power after starting
   - QinetiQ Fog Carburetor
     - Heats fuel/air mixture before ingestion into cylinder
     - Uses exhaust gas in the fog chamber

   - Sonex HFE –
     - Vaporizes "fuel droplets" in the combustion cylinder
     - Uses the "residual heat" in cylinder from previous combustion

QinetiQ Fog Carburetor

Combustion Solution - QinetiQ Fog Carburetor

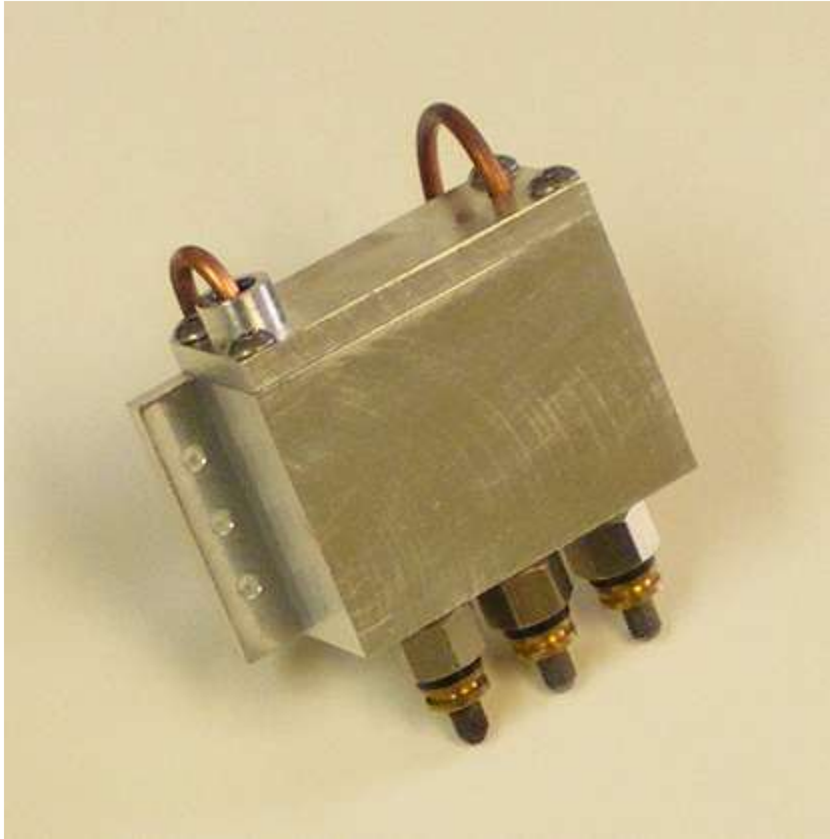
Characteristics of operation

- Fuel enters a separate heated chamber – vaporized to a fog – ingested into cylinder as air/vapor mix
- Chamber heated with electricity to start, switches to hot exhaust gas after starting (T>400 deg F)
- Electricity to “trim” the temperature for control

Works “fairly well” –

- “Proof-of-Concept” units for early customer feedback
- Needs a lower compression ratio to avoid knocking
  (an “issue” with Honda)
- A bit “fussy” to control (elevation and temperature)
- At “low temperatures” – fuel-in-oil becomes an issue.
  Fog condenses in cold engine cylinder

Sonex Cold Start Vaporizer (CSV)



Sonex vaporizer as installed in Honda Gen Set

Sonex Vaporizer

Characteristics of operation

- Fuel enters an electrically heated coil – vaporized for starting
- Switches to normal carburetion when the cylinder is “hot”
- Maintains cylinder head temperature for combustion

Works “quite well”

- Can run with COTS compression ratio – no steady-state knocking problem
- Can achieve COTS carburetor performance when hot
- Developed for Scan Eagle UAV – validated for 2-stroke engines
- (Has the same “fuel-in-oil issue” at cold temperatures)

Interesting Mechanics

- Unburned fuel collects on top of piston
- Is “thrown” up against the hot cylinder head and valves
- Vaporizes – (like spitting on a hot iron) - Spark ignites
- Stratifies the charge – no compression heating and pre-ignition

Collaboration

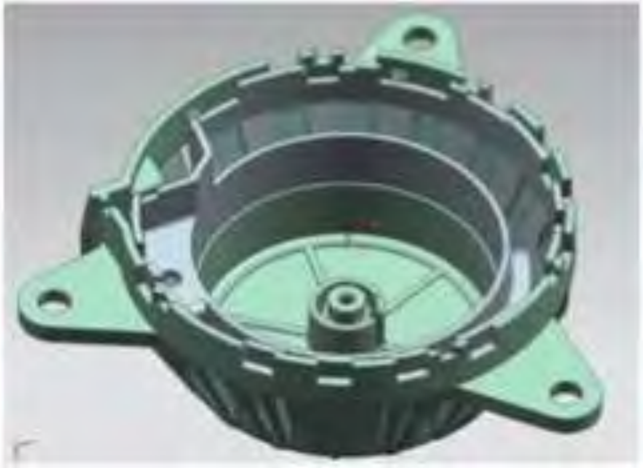
Key achievements from QinetiQ/ Sonex collaboration:

- Recognition that if cylinder temp is kept at ~400 deg F
  - The cylinder acts like the QinetiQ fog chamber !
- If temperature is controlled, fuel-in-oil issue is resolved !
  - All the fuel is burned
- Demonstration that active control of cooling airflow actually works.
  - Cold start – handoff to carburetor
  - Cold operation – maintain cylinder temp
  - Hot operation – equal to COTS cooling

Airflow Control

Fan inlet – COTS unit

Damper – open/ closed



Airflow Control

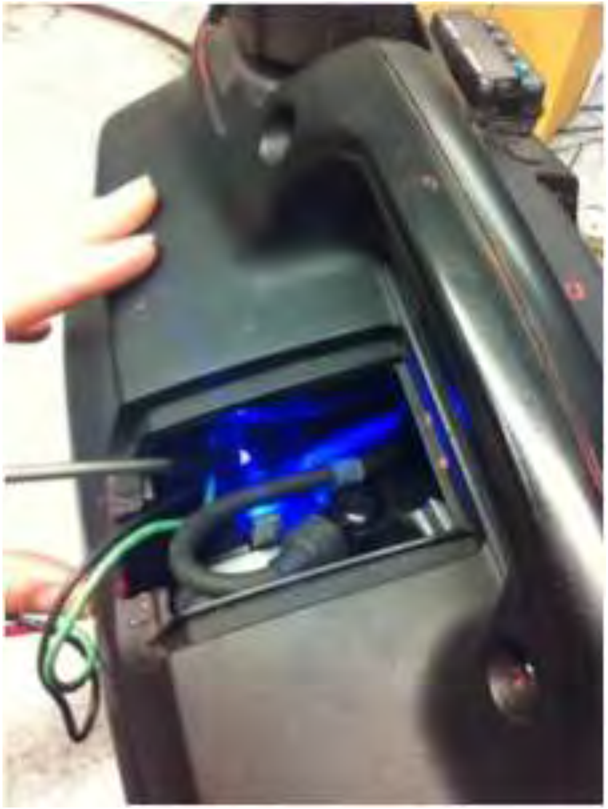
Rise over Ambient deg F	No Load	500w load
COTS Airflow	217°	278°
-20% Airflow	256°	330°
No Airflow	417°	Way too hot

<u>Key for operation on Heavy Fuel:</u>
cylinder temperature >354° F

Airflow Controller

Cold Temperature "hand-off"

Time to reach 215° F, after starting	10° F	0° F
No load, -20% airflow	~6 min	~10 min
No Load, no airflow	~2.5 min	~3 min
500w AC load, no airflow	~1 min	~1.5 min

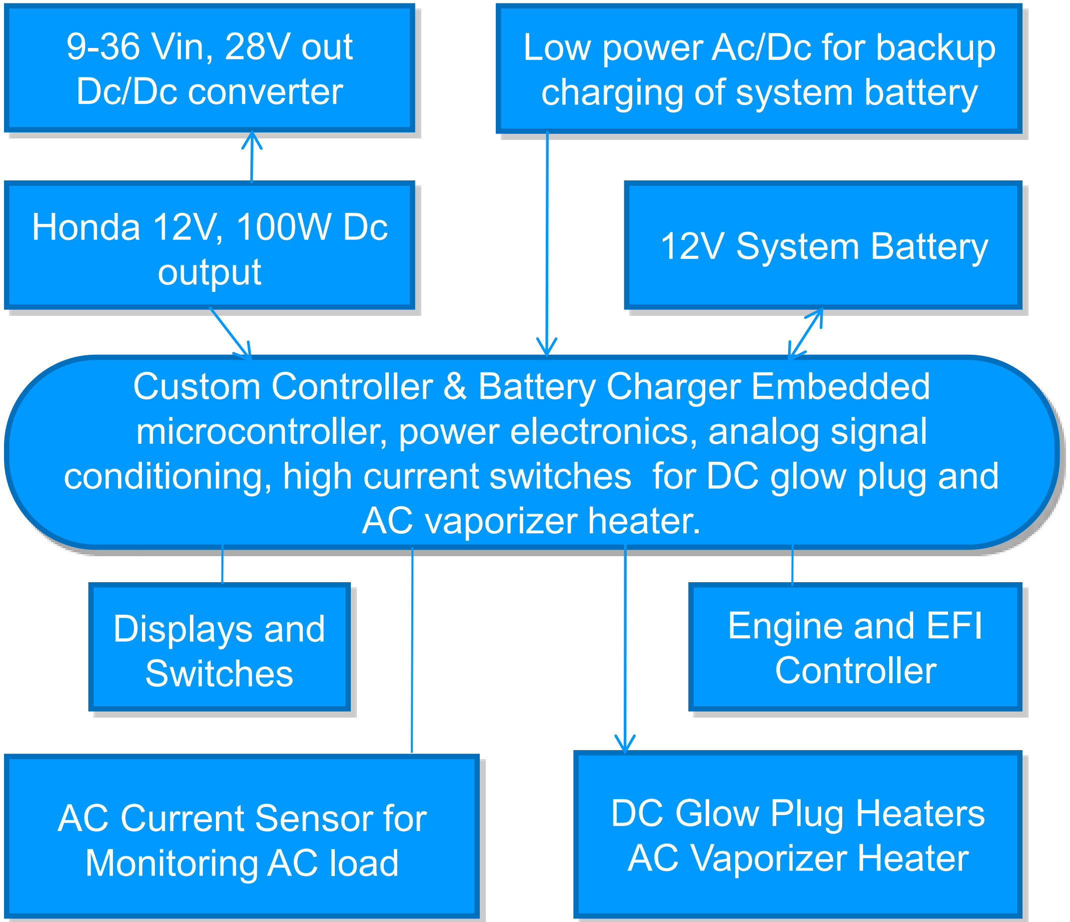


Critical Hand-off temperature:
cylinder temperature >215° F
for operation on carburetor

Target time to hand-off < 1.5 Min

Solution = heat with AC after start

Control and power switching



Product definition

Mod-1:

- Carburetor, near COTS
- JP8 fuel only
- Resolve feature set and specifications
- Voice of the customer
- LRIP units available 2011

Mod-2:

- Fuel Injector, new case
- Multiple fuels - heavy and gasoline (JP8, Jet A, DF2, gas)
- Specific “improvements”
  - Filtering for sand and dust
  - EMI suppression
  - Enhanced performance at altitude and temperature
- LRIP units available 2012

Mod-2: Multi-fuel Feasibility Assessment

Honda Engine with vaporizer and fuel injector

Mod-2: Multi-Fuel Solution

<u>Fuel Injection is the ultimate solution</u>

- More robust than Carburetion
- Operate on any fuel – no viscosity or flow problems
- Can control for temperature, altitude better
- Proven technology –
  - Flying on 2-stroke UAV engines
  - In volume production on low cost motorbikes
- Starting and temp control – same as Mod-1
- Same low cost solution

Feature set and specifications

Mobility: Single-Man-Portable (<40 lbs)

Fuel: Mod-1: JP8 only

Mod-2: Multi-fuel (JP8, DF2, Jet A, Gasoline)

Output Power: 110VAC – 1,000 Watts (1Kw)

24 VDC – 100 Watts

Noise: <64dBA @ 7 meters

Weight: (dry/Wet): 36 lbs / 39 lbs

Size: L=19”, W=9.5”, H=16”

Minimum Starting Temp: 10° F **Operating Temp:** -10° F to +125° F

Altitude: 1kW @ MSL, de-rated up to 6000ft

Fuel Capacity: 5 hours @ 80% Load (0.12 gal/hr)

How to get one

MEP is consolidating demand for Mod-1 units

- Call Dick Carroll – 270-719-1273
- Dick.carroll@qinetiq-na.com

Some other notes:

- Expected life ~1,000 hrs.
- Unit will alert for replacement
- Scheduled Honda maintenance – available as service

Appendix:

Since Everyone Loves to discuss the Technical Stuff….

See us at the Booth

Next Generation BA5X90 Battery

Carlos Negrete-New Technologies Engineering Manager

Valdese, NC

Agenda

1. Saft Overview
2. Saft Hybrid Technology overview
3. BA5X90 performance
4. Future Development (next generation systems)
5. Questions

Saft World Wide

Specialty Battery Group production site
High-performance, primary and rechargeable lithium and silver batteries for the electronics, defence and space industries.

Industrial Battery Group production site
Rechargeable nickel and lithium-based batteries for demanding industrial applications.

Saft sales network

ASB
(50% Saft, 50% EADS)

Johnson Controls-Saft
(Saft 49%, Johnson Controls Inc. 51%)

Sites under construction

With 4,000 employees worldwide,
Saft is present in 18 countries.

Saft is focused on the needs of our soldiers

- Saft has been a major supplier for the US Army for batteries used by the soldiers for last 20+ years
- We have supplied millions of batteries to the soldiers to support their critical missions
- Saft offers a wide range of high energy/high power technologies used by the soldiers in multiple applications
  - Li-SO2
  - Li-MnO2
  - Li-Ion
- We understand the military market and its unique requirements

1 Saft Hybrid Cathode Systems

Program History

- In 2008, through funding provided by the US military, Saft started a development program to create a cathode system capable of delivering higher discharge capacities with similar properties to current Lithium MnO_2 systems
- The new design utilizes a mix of MnO_2 and CFx(carbon-mono fluoride) as cathode material with similar cell components and construction as in Li-MnO_2
  - > Capable of delivering significantly higher energy density
    - More capacity and lower weight burden
    - Increased performance at low temperature
  - > Similar level of safety as standard MnO_2

Why Hybrid Technology?

Lithium MnO_2

- Low to high drain rate
- Good energy density
- No startup delay
- Low cost

Lithium CFx

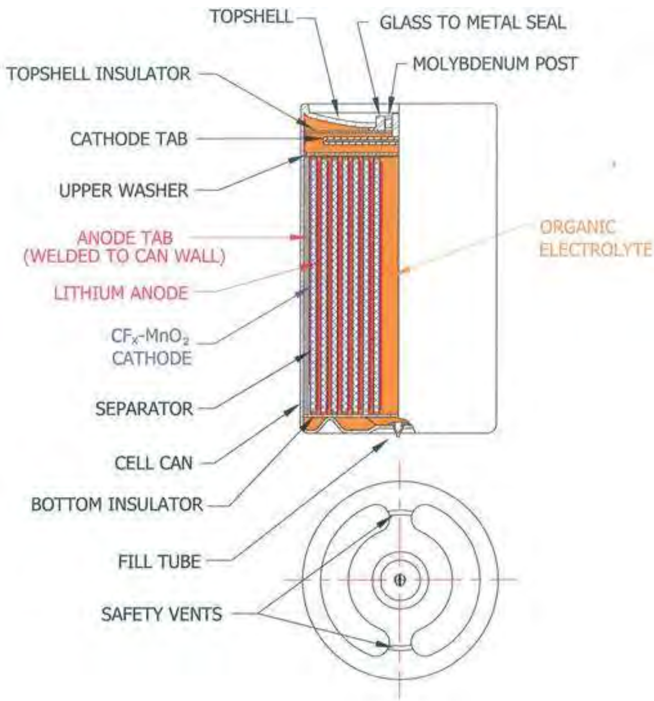
- Low drain rate
- High energy density
- Excellent at low temperature
- High material cost

Hybrid MnO_2/CFx

- Low to high current discharge
- 350-400 Wh/kg
- No Startup Delay
- Excellent low temperature performance
- Lower cost than pure CFx

LH33550 Cell Design

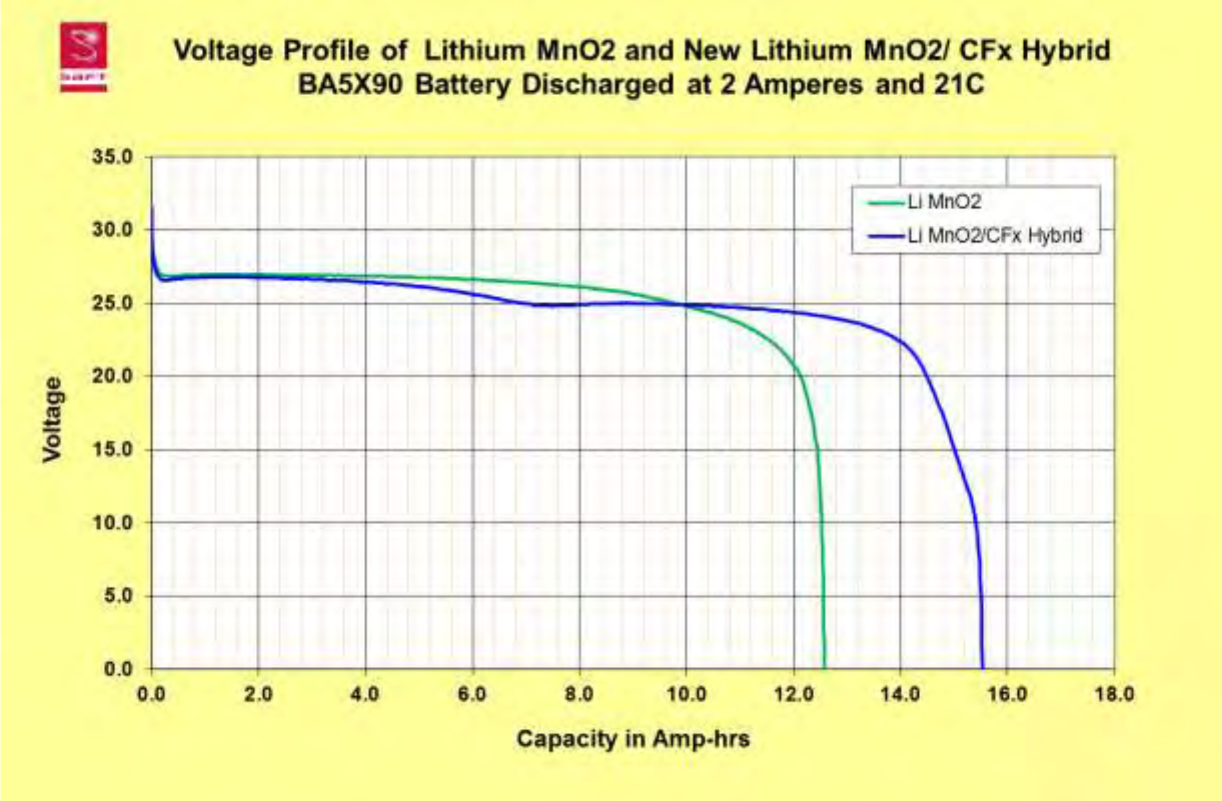
- Lithium Limited Design
- Hardware- **Same as Li/MnO_2**
- Cathode Active Material: EMD:CFx
- 25µ Tri-layer Separator
- Safety Vent
- Total Cell Weight: 106 grams
- Nominal OCV: 3.17 volts
- Cell internal Resistance: ~75mΩ (Based on 10A/5S Pulse)
- Rated Capacity
  - At 2A Rate at 21°C: 14.5 Ah
  - At 250mA Rate at 21°C: 15.5 Ah



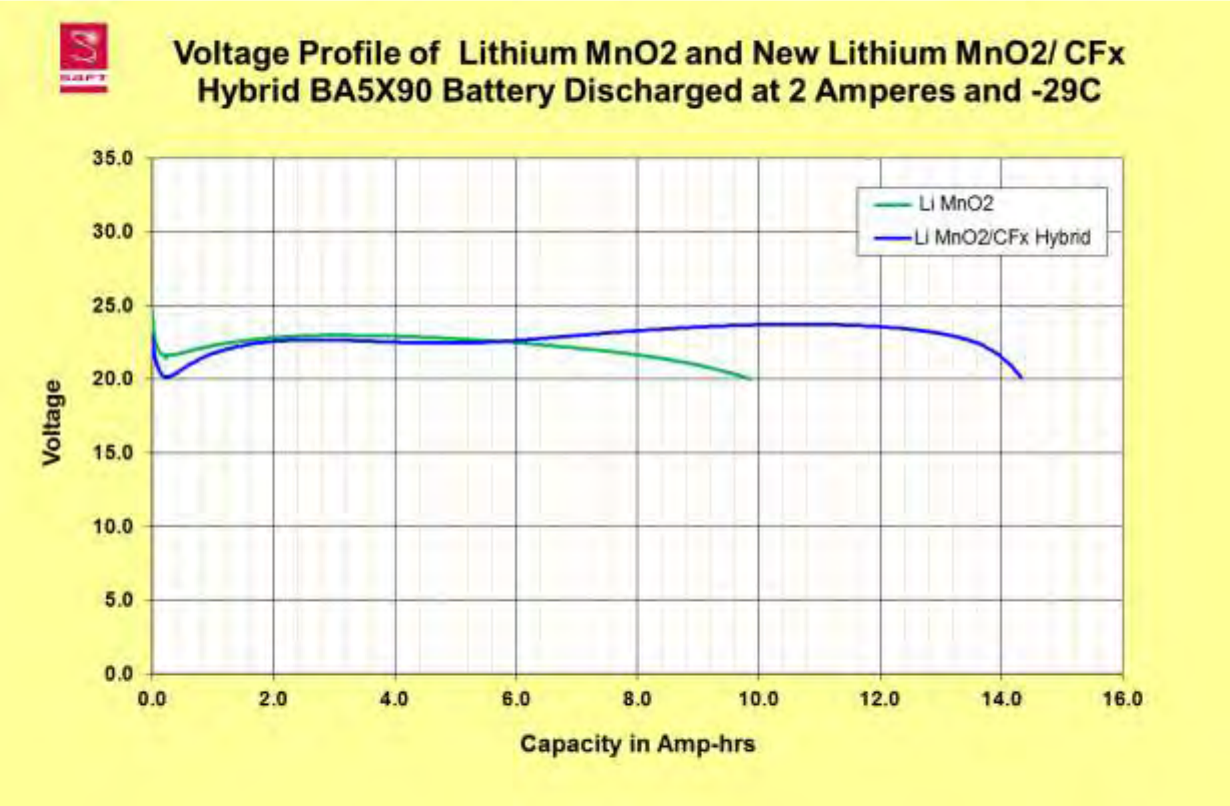
2

BX590 Performance

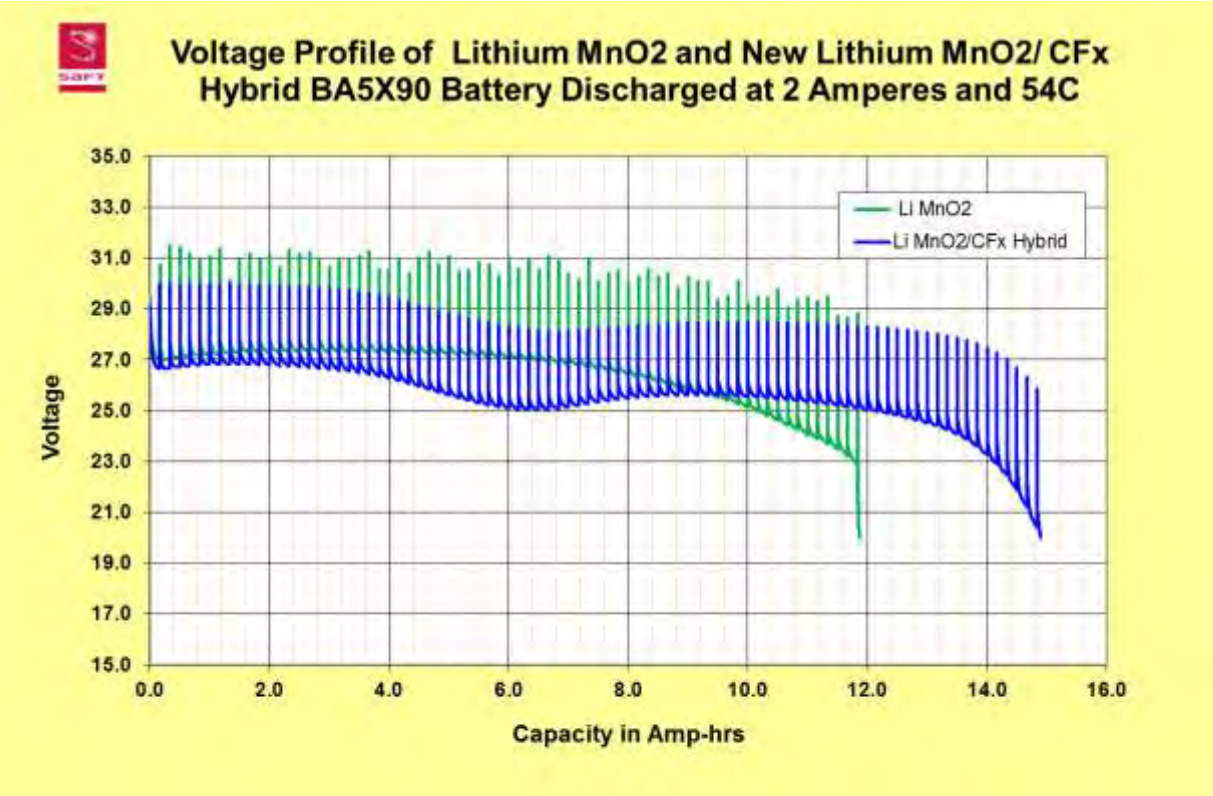
Saft Generation I BA5X90 I Test (MIL-PRF-49471B)



Saft Generation L BA5X90 I Test (MIL-PRF-49471B)



Saft Generation H BA5X90 I Test (MIL-PRF-49471B)



3

Ongoing Development

Areas of ongoing development

- Management of heat generation
  - > CFx material generates heat throughout the discharge of the battery and must be managed
- Increase the energy density by lowering the weight burden through the use of low weight materials
- Higher active material content through
  - > Elimination of void/unused space
  - > Higher cathode loading through increased densification

BA5X90's Capacity and Energy Density Comparison

Chemistry	Capacity	Weight	Energy Density
	(Amp hrs)	(grams)	Wh/kg
LiSO2	8.5	1020	215
LiMnO2	12.0	1420	245
Hybrid (Today)	14.5	1280	285
Next Gen Hybrid (Future)	15.5	1110	350

2A Discharge at 21 C

saft

Relative cost comparison on BAX590 batteries

- Comparing different BX590 technologies in relation to dollars spent / energy delivered the traditional BA5590(SO2) still has a clear advantage. The newer technologies with enhanced energy density comes with a significant premium
  - > BA 5590 (SO2) 100
  - > BA 5390 (Mn02) 140
  - > BAX590 (Mixed Oxide) TBD
    - – (higher than the current technologies)

Acknowledgement

- Saft sincerely appreciates all CERDEC personnel for their support and patience, specially the following:
  - > Mike Brundage-Power Sources, Branch Chief
  - > Chris Hurley-Team Leader, Battery Technology Development
  - > Deanna Y. Tyler-Mechanical Engineer
- Saft personnel involved in the program
  - > N.S. Raman
  - > Allan Davenport
  - > Dr. Bernard Simon
  - > Dr. Robert Staniewicz

4

Questions

Recent Advances with Lithium Carbon mono-fluoride Batteries for Portable Applications

Gregg C. Bruce and Mario Destephen
EaglePicher Technologies

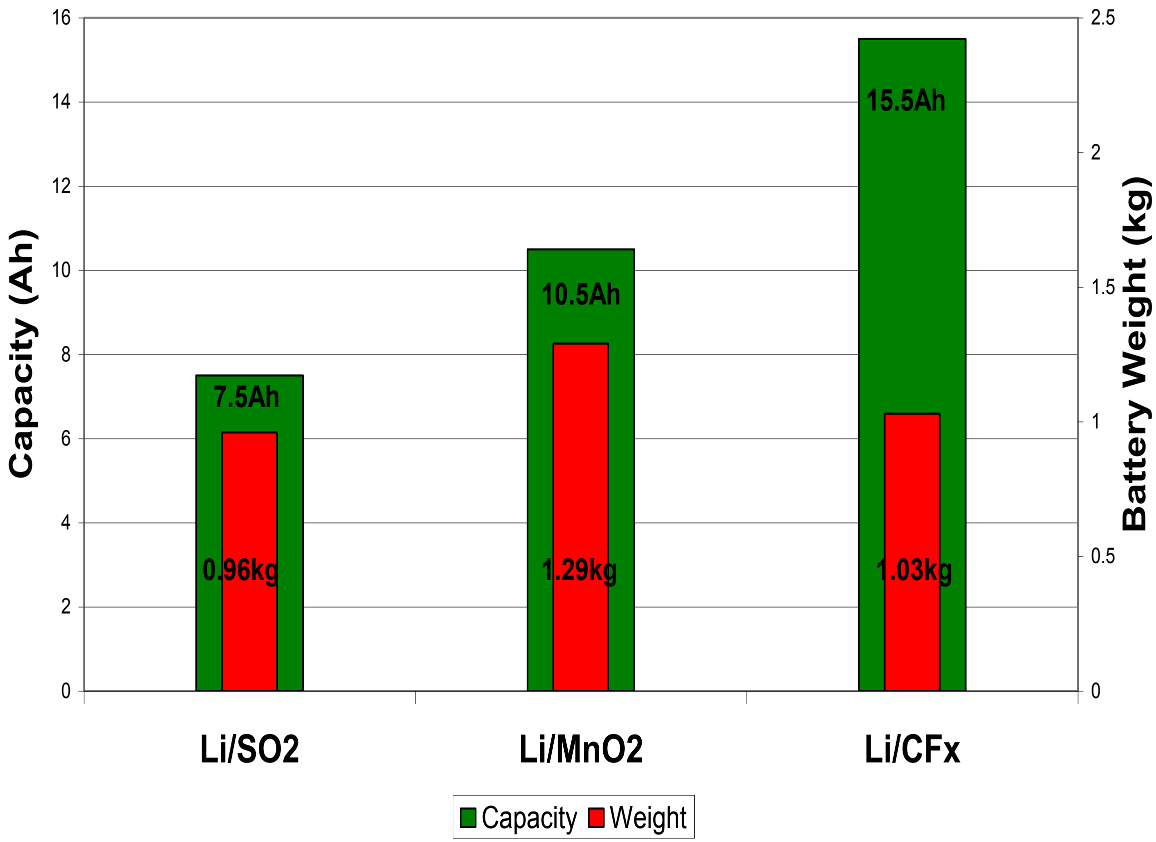
Joint Services Power Expo
May 4th, 2011

Topics

- Introduction to Li/CFx
- "Half-Sized" BA-5590 Li/CFx Battery Development
  - Phase I – Steel Cell Development and Limited Battery Testing.
  - Phase II – Aluminium Cell Development and Additional Safety and Battery Testing.
- Conclusions

Hi Power CFx Cell Development @ EPT

- Initial target is a D cell with 2X Specific Energy compared to the current Li/SO_2 and Li/MnO_2 batteries at the required 2A continuous discharge rate.



Half BA5590
½ size / similar energy

Challenges

EaglePicher Technologies, LLC

- Low temperature performance and heat management are recognized as the major challenges for this application.
- Significant improvements have been made in low temperature performance, but initial voltage delay still needs improvement for low temperature high rate applications.
- Heat management at the BA-5590 battery level is still a concern for high rate continuous operation.
- CFx material cost continues to be a concern for high volume applications.

Other Improvements

- Aluminium hardware provides an increase of >100 Wh/kg in specific energy density.
  - Reduction by 21% in weight.
- Welded design with rivet seal provides a robust design for high temperature operation.
- Extensive performance, safety and transportation testing has been successfully completed with this design.
- All UN transportation tests - 28 days desert cycle.

D cell with Al Hardware
Length = 54.6 mm
OD = 33.1 mm

Baseline Phase I – Design Attributes

EaglePicher Technologies, LLC
An OM Group Company

Phase I – ½ Sized BA-5590 Li/CFx

- *Mild steel cell enclosure.*
- *Standard feed through and welding processes.*
- *Proof of Concept.*

Attribute	US Army Performance Specification (Half-90)	EaglePicher Energy Products Half-90 Performance
Energy	200 Wh at SINCGARS (30.5 hours)	170 Wh at SINCGARS (26.2 hours) Ambient 184 Wh at 55°C
Weight	1.1 pounds (0.499 kg) (400 Wh/kg)	1.07 pounds (0.485 kg) (350 Wh/kg)
Dimensions	2.450” x 2.500” x 4.400”	2.435” x 2.490” x 4.390”
Voltage	16.8 V (10V cut-off)	16.5 V (10V cut-off)
Connector	BA-5590 Type	BA-5590 Type
Fuel Gauge	State of Charge Indicator	State of Charge Indicator
Operational Temperature	-20°C to 55°C	-20°C to 55°C (voltage delay noted at -20°C)
Storage Temperature	-40°C to 70°C	-40°C to 70°C
Transportation and SAR	Required before FY09 Soldier use	UN Transportation Tests compliant; SAR testing is required for Phase II

Phase II – Changes/Challenges

EaglePicher Technologies, LLC

Phase II – ½ Sized BA-5590 with Li/CFx Cells.

- Phase II was focused on additional testing of the battery to understand performance and safety.
- Outlined potential of Aluminium hardware as an option.
- Program refocused to Aluminium hardware development (LC-3155 Slim D).
- There were some design change issues which had to be addressed but the major issues were welding related.
- Phase II also carried out more testing according to that outlined in the First Article Tests and Safety Assessment Report, but not a full FAT/SAR.

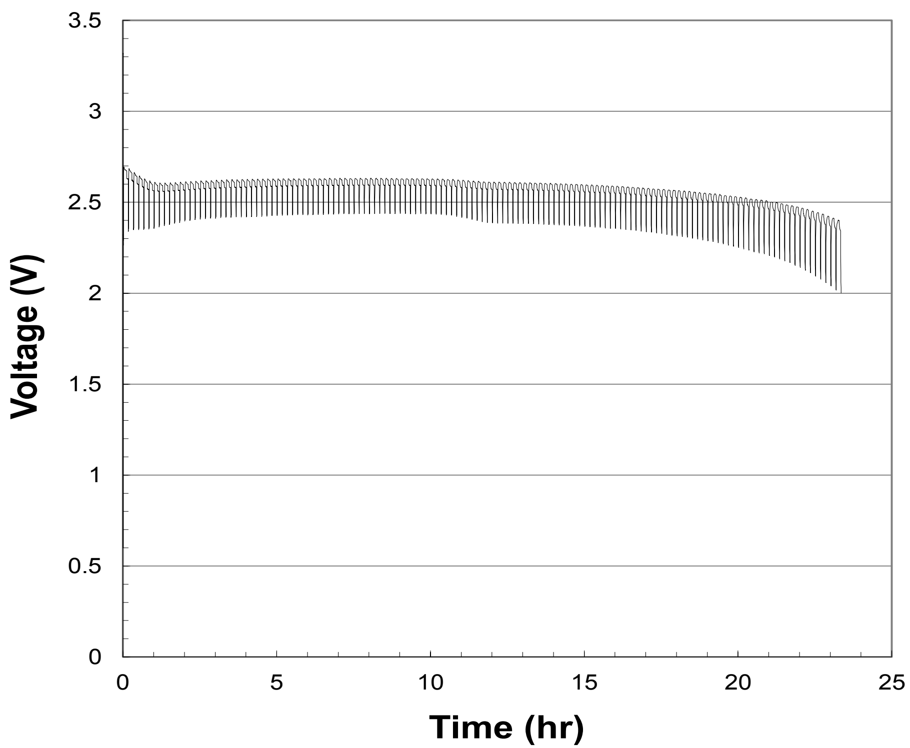
Phase II – Cell Design Attributes

EaglePicher Technologies, LLC
An OM Group Company

- Aluminium hardware provides a weight advantage but due to material selection there are some other concerns:
  - Rivet seal replaces a more conventional Glass to Metal seal.
  - Cell is 23% lighter when compared to the Phase I design.
  - Slim D cell has passed the UN Transportation requirements.
  - Slim D cell was tested for some FAT and SAR requirements.

Phase II – Cell Testing

- Cells tested under the SINCGARS Protocol after 28 Day Desert Cycle lost 2.1%Wh and 1.2% Ah.
- SINCGARS discharge protocol at 21°C provided.



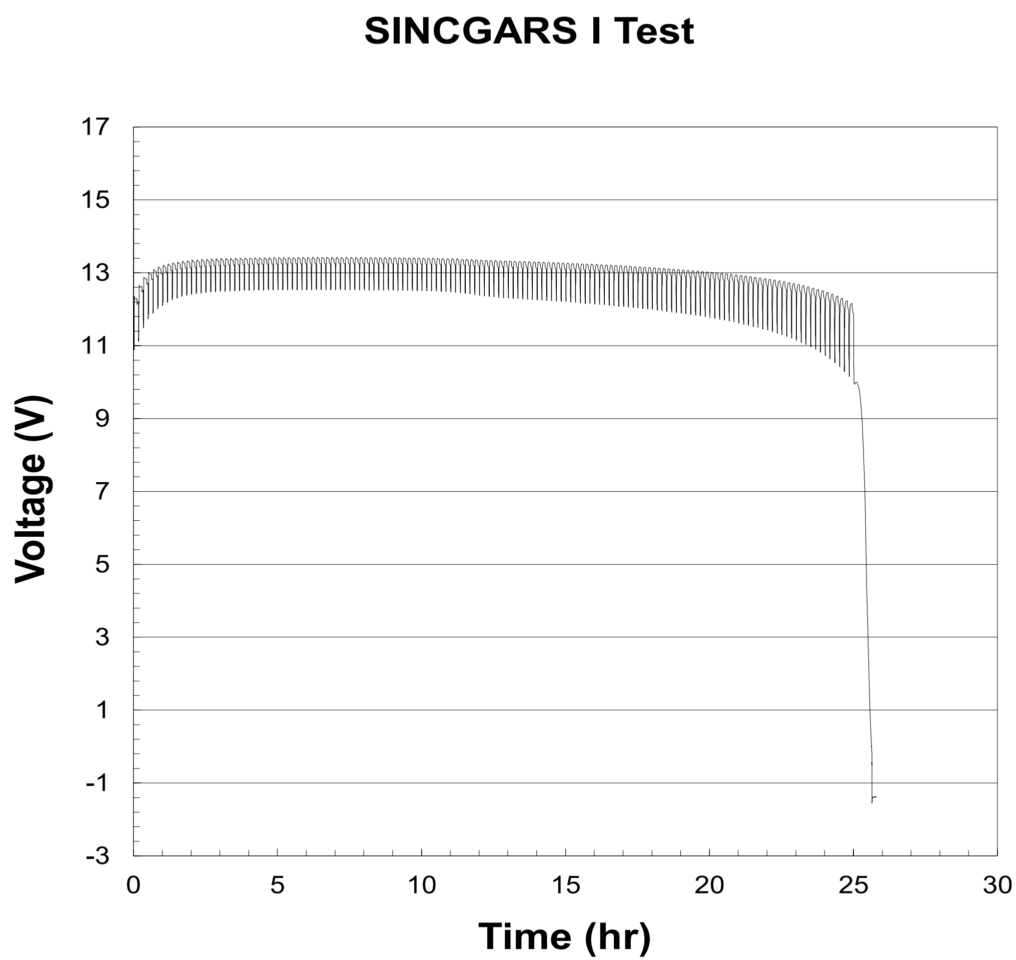
Phase II – Cell Testing

- **Aluminium Cells passed the following abuse tests:**
  - **UN Transportation Requirements:**
    - **T1 – T5 (Altitude, Thermal, Vibration, Shock, Short-Circuit).**
    - **T6 – Impact.**
    - **T8 – Forced Discharge.**
  - **Desert Cycle – Cell leakage.**
  - **Cell Charging - 20 mA for 96 hours.**
  - **Nail Penetration – 5 full penetration and 5 2/3 penetration**
    - **Full maximum of 107°C.**
    - **2/3 maximum of 137°C.**
    - **No fire or disassembly.**

- Battery assembly was developed to deal with aluminium hardware.
- Battery weight was reduced by approximately 19%.
- Volume is 50% of the BA-5590.
- Finished battery now weighs < 400g.
- Weight is 41.1% of a BA-5590B/U

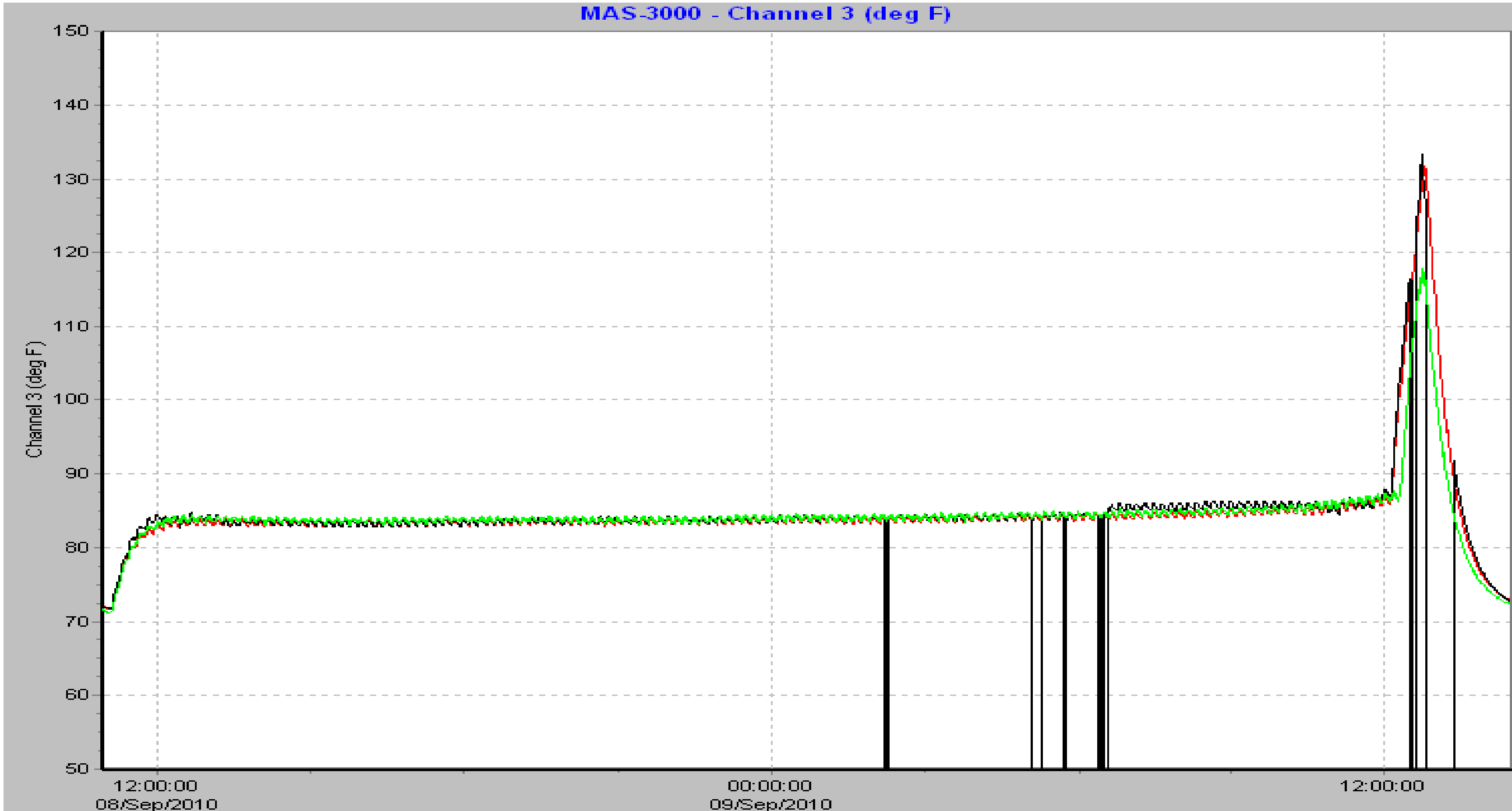
EaglePicher Technologies, LLC
An OM Group Company

- Under the I Test condition the battery delivered 164.6 Wh, 12.90-Ah and ran for 25.08 hours.



Phase II – Battery Testing – Thermal Profile I Test

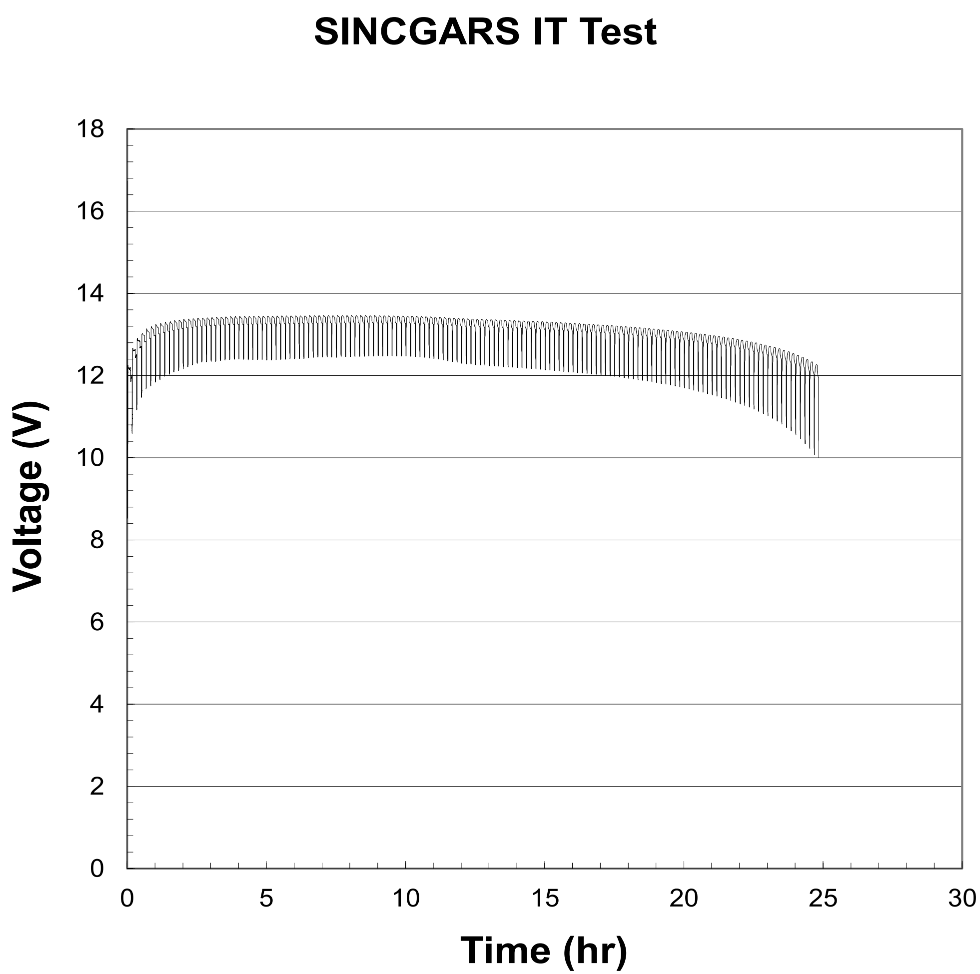
EaglePicher Technologies, LLC



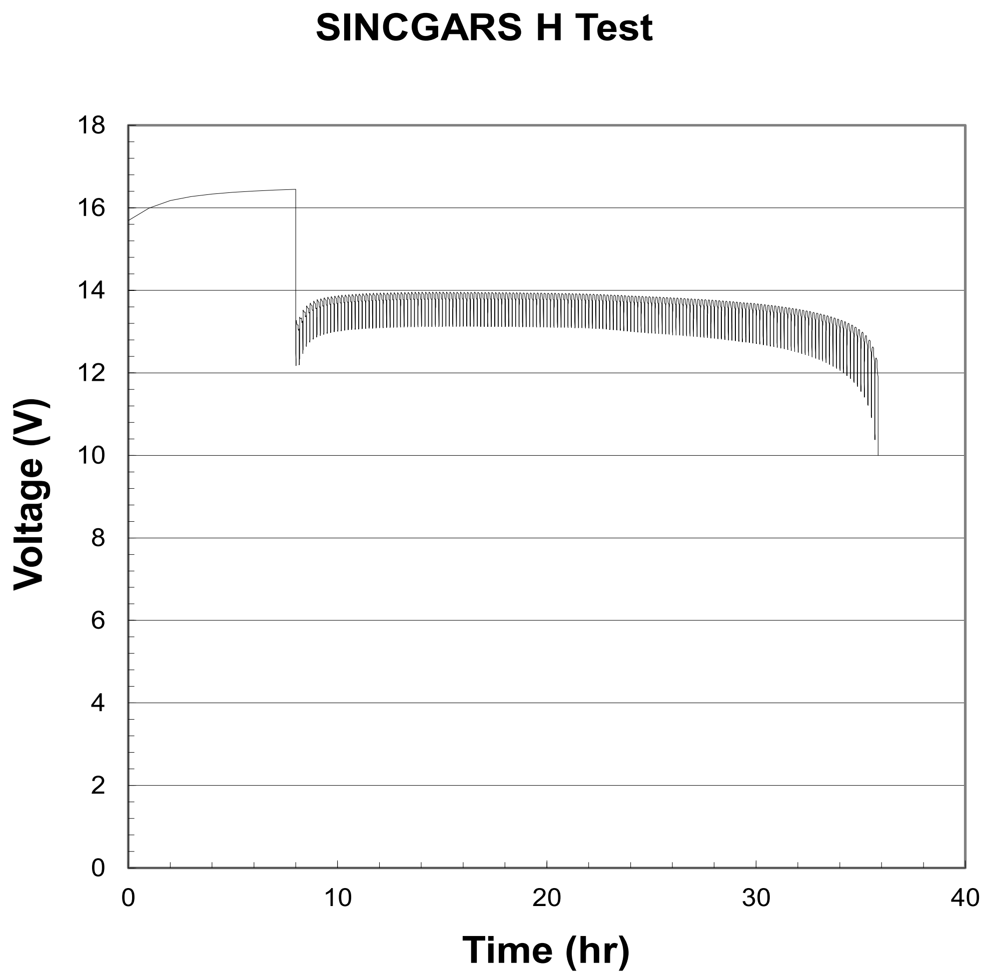
Company	Plot	Folder	Recording	Chan	Ch. Label	Type	Recording start	Recording size	Remark	Operator
EaglePicher	(red)	B590AL CAPACITY	I	1	Channel 1	deg F	8 Sep 2010 (10:56:01 am)	9912 samples at 10 Secs		Robert Plucinski
EaglePicher	(black)	B590AL CAPACITY	I	2	Channel 2	deg F	8 Sep 2010 (10:56:01 am)	9912 samples at 10 Secs		Robert Plucinski
EaglePicher	(green)	B590AL CAPACITY	I	3	Channel 3	deg F	8 Sep 2010 (10:56:01 am)	9912 samples at 10 Secs		Robert Plucinski

- **For the I Test 10 minutes FOD after 0V is required.**
- **Two of the batteries met this condition one did not.**
- **External Temperature reached a maximum of 134°F (56°C).**

- Under the IT Test condition the battery delivered 164.9 Wh, 12.88-Ah and ran for 25.12 hours.

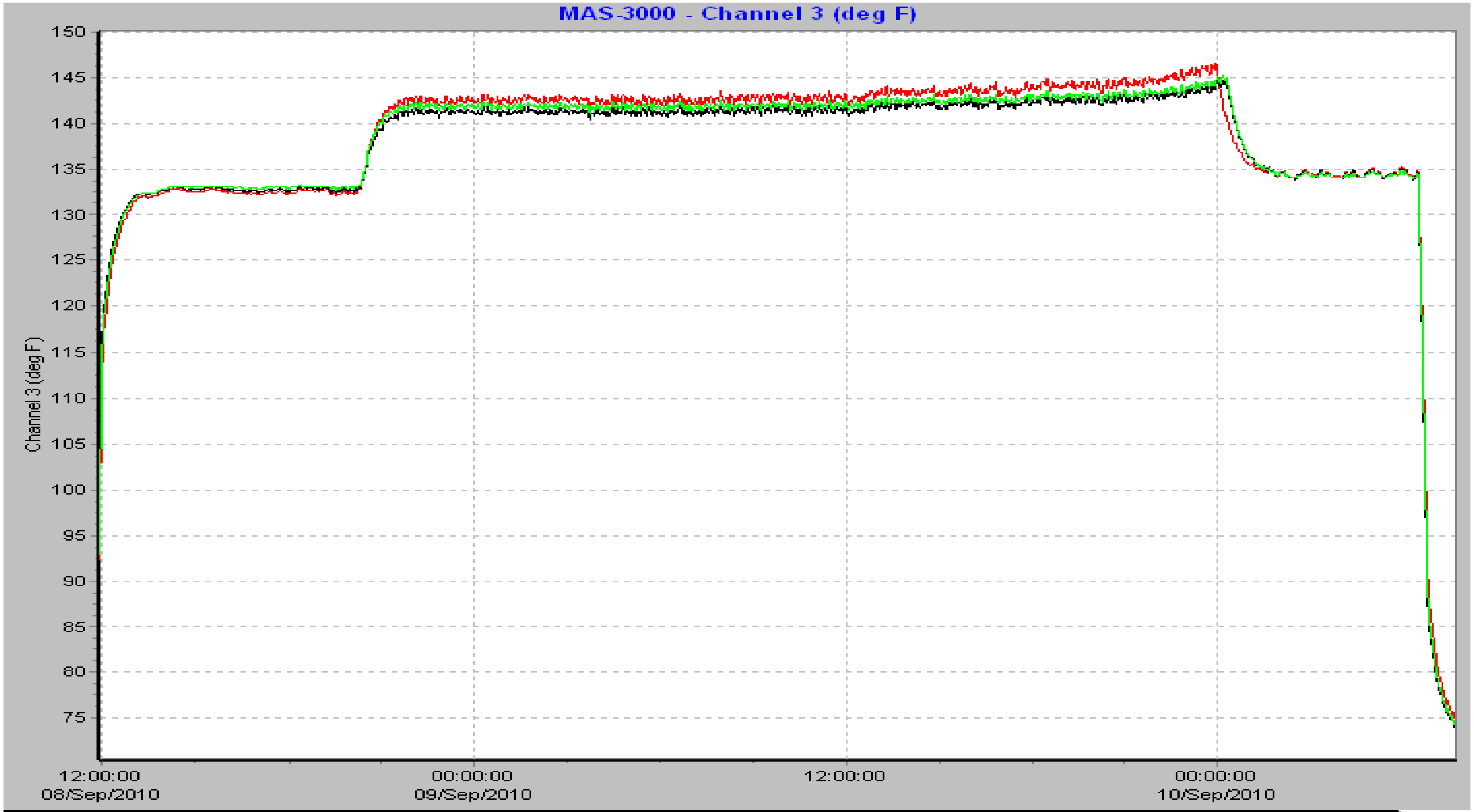


- Under the H Test condition the battery delivered 181.9 Wh, 13.58-Ah and ran for 27.73 hours.



Phase II – Battery Testing – Thermal Profile H Test

EaglePicher Technologies, LLC

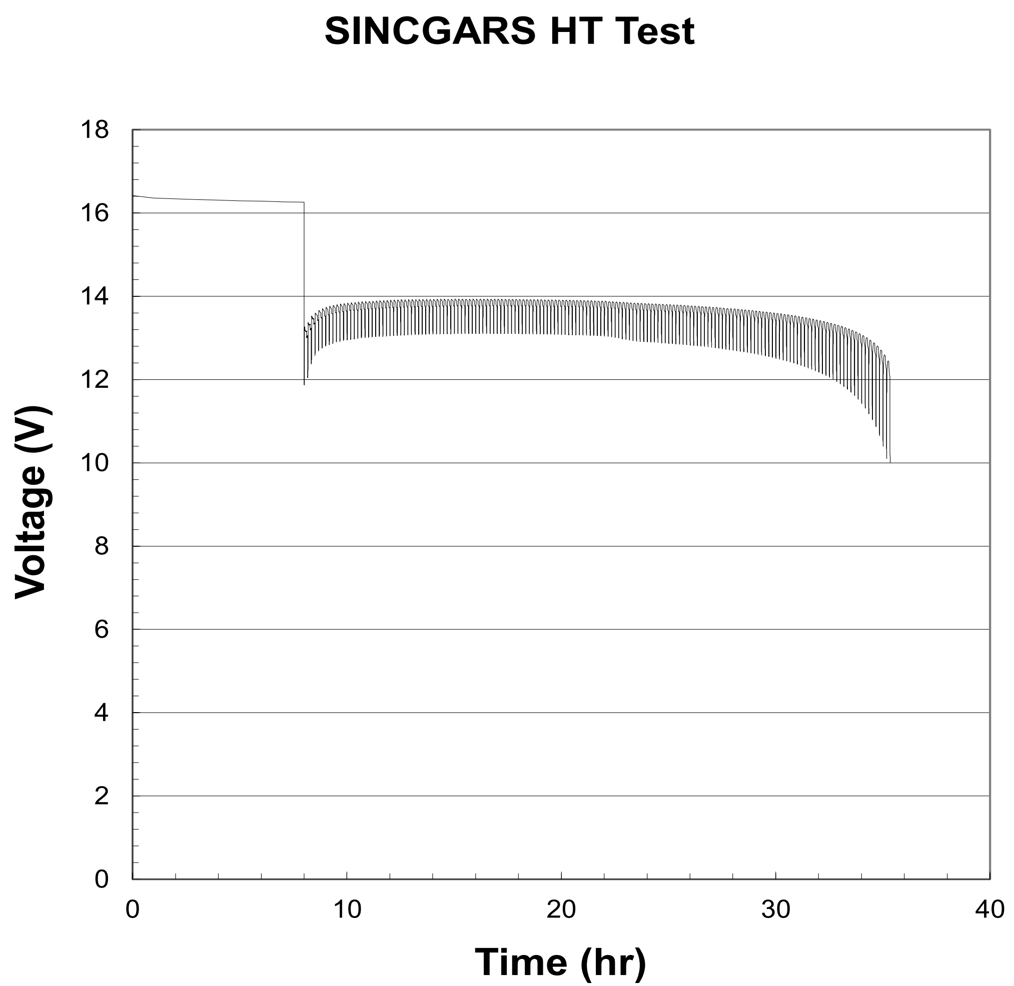


Company	Plot	Folder	Recording	Chan	Ch. Label	Type	Recording start	Recording size	Remark	Operator
EaglePicher		B590AL CAPACITY	H	1	Channel 1	deg F	8 Sep 2010 (11:55:52 am)	15738 samples at 10 Secs		Robert Plucinski
EaglePicher		B590AL CAPACITY	H	2	Channel 2	deg F	8 Sep 2010 (11:55:52 am)	15738 samples at 10 Secs		Robert Plucinski
EaglePicher		B590AL CAPACITY	H	3	Channel 3	deg F	8 Sep 2010 (11:55:52 am)	15738 samples at 10 Secs		Robert Plucinski

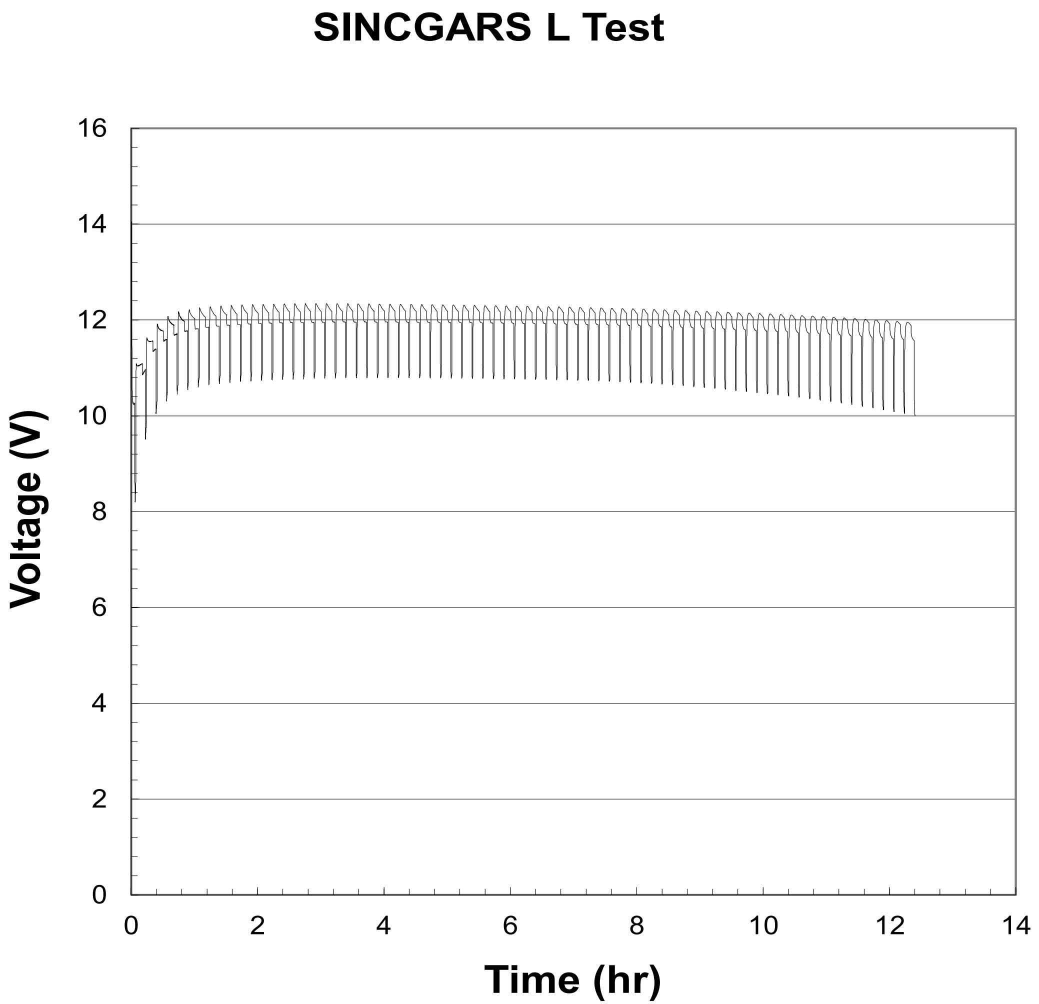
- **No FOD Requirement.**
- **Maximum temperature reached was 146°F.**

Phase II – Battery Testing – HT Test

- Under the HT Test condition the battery delivered 179.8 Wh, 13.46-Ah and ran for 27.40 hours.



- Under the L Test condition the battery delivered 81.43 Wh, 7.07-Ah, 12.39 hours and 20 minute Voltage Delay.



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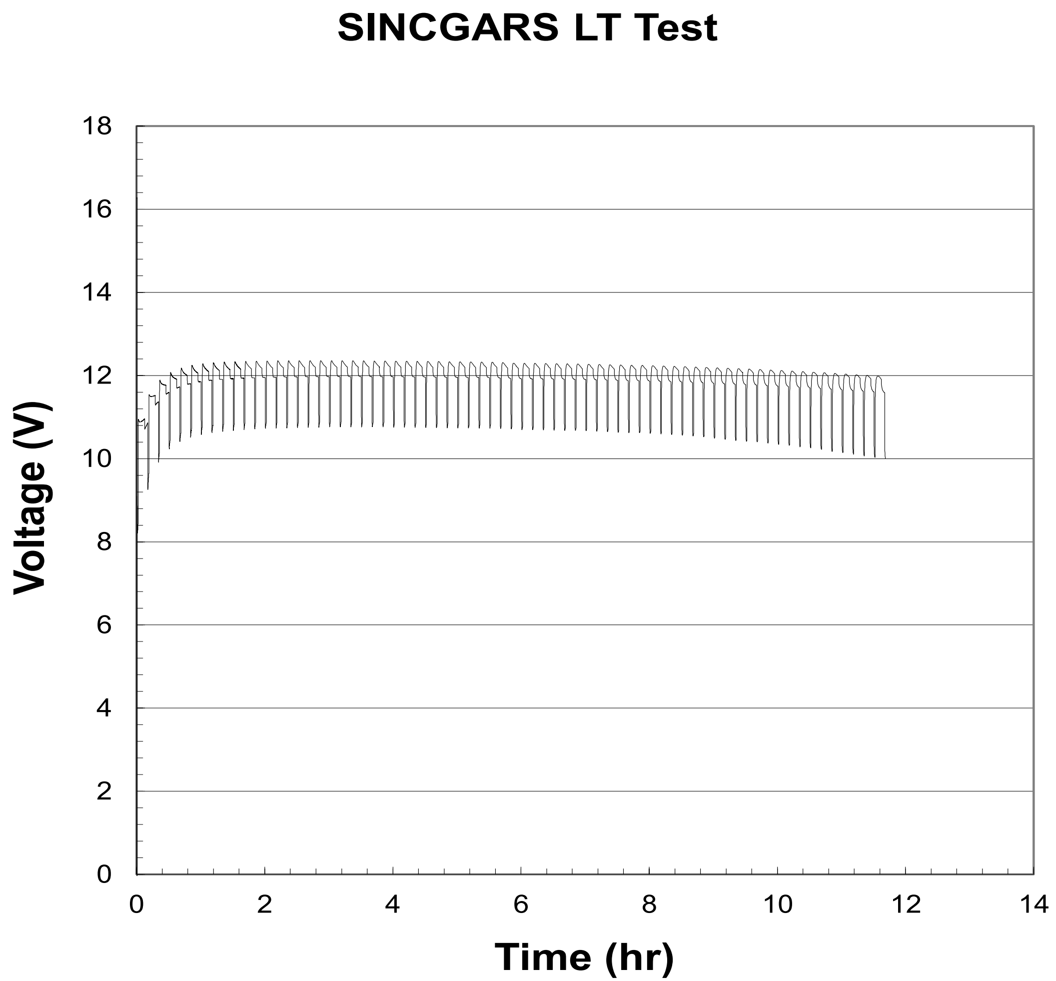
An OM Group Company

- Under the LT Test condition the battery delivered 76.74 Wh, 6.65-Ah, 11.68 hours and 20 minute Voltage Delay.



SINCGARS Performance – ½ Sized BA-5590
No Storage (I, L and H)

Temp (°C)	Delay (min)	Min volt drop	Capacity (Ah)	Energy (watt-hrs)	Specific Energy (Wh/kg)	Energy Density (Wh/L)	Discharge time (hr)
-20	20	6.24	7.07	81.43	205.63	184.40	12.39
21	0.0	10.86	12.90	164.60	415.66	372.74	25.08
55	0.0	12.13	13.58	181.91	459.37	411.93	27.73

SINCGARS Performance – ½ Sized BA-5590
After 7 Days Desert Cycle Storage (LT, IT and HT)

Temp (°C)	Delay (min)	Min volt drop	Capacity (Ah)	Energy (watt-hrs)	Specific Energy (Wh/kg)	Energy Density (Wh/L)	Discharge time (hr)
-20	20	0.00	6.65 (94.1%)	76.74 (94.2%)	193.54	173.78	11.68
21	0.0	8.88	12.88 (99.8%)	164.92 (100%)	415.42	373.46	25.12
55	0.0	11.94	13.46 (99.1%)	179.80 (99.85)	452.91	407.16	27.40

Phase II Performance versus Goals

Attribute	US Army Performance Specification (Half-90)	EaglePicher Energy Products Half-90 Performance
Energy	200 Wh at SINCGARS (30.5 hours)	165 Wh at SINCGARS (25.08 hours 21°C) 182 Wh at SINCGARS (27.73 hours 55°C)
Weight	1.1 pounds (0.499 kg) (400 Wh/kg)	0.87 pounds (0.395 kg) (415 Wh/kg)
Dimensions	2.450” x 2.500” x 4.400”	2.450” x 2.500” x 4.400”
Voltage	16.8 V (10V cut-off)	16.75 V (10V cut-off)
Connector	BA-5590 Type	BA-5590 Type
Fuel Gauge	State of Charge Indicator	State of Charge Indicator
Operational Temperature	-20°C to 55°C	-20°C to 55°C (voltage delay noted at -20°C)
Storage Temperature	-40°C to 70°C	-40°C to 70°C
Transportation and SAR	Required before FY09 Soldier use	UN Transportation Tests compliant; SAR testing is required for Phase II

Summary

EaglePicher Technologies, LLC
An OM Group Company

- **High Energy D Size CFx cell has been developed with the energy and rate capability for the BA-5590 battery application**
  - **2X energy advantage over Li/SO_2 and Li/MnO_2.**
  - **Significant improvements in low temperature operation.**
  - **Aluminium hardware provides additional gain in specific energy.**
- **Hybrid chemistry being developed by EPT Joplin offers the opportunity to expand technology to other applications**
  - **Lower total battery material cost.**
  - **Improves voltage delay and heat management for portable power.**

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Li-CF_x/MnO_2 Hybrid D-cell with Wide Operating Temperature Range for Military Batteries

Xinrong (Ron) Wang and David Modeen

Outline

- Introduction
- Objective
- Design of Li-CF_x/MnO_2 Hybrid Chemistry
- Phase I D-Cell Performance
- Phase II D-cell Performance
- Summary
- Acknowledgement

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Introduction

Design, Manufacture, Install & Maintain
Power and Communications Systems

- Battery & Energy Products
- Communications Systems

Government, Defense & Commercial Markets

Ultralife Batteries, ABLE
McDowell, RedBlack, AMTI

Headquarters in Newark, NY
Sales & Operations in US, Europe and Asia

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Objective

- **Develop Li-CF_x/MnO_2 Hybrid D-cells into Different Formats of Military Batteries**

Goal:

1) High Capacity
2) High Power
3) Light Weight (High Energy Density)
4) Wide Operating Temperature Range
5) Long Shelf Life
6) Cost Effective
7) Safe (Robust)

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Objective

D-cell in BAxx90 Battery

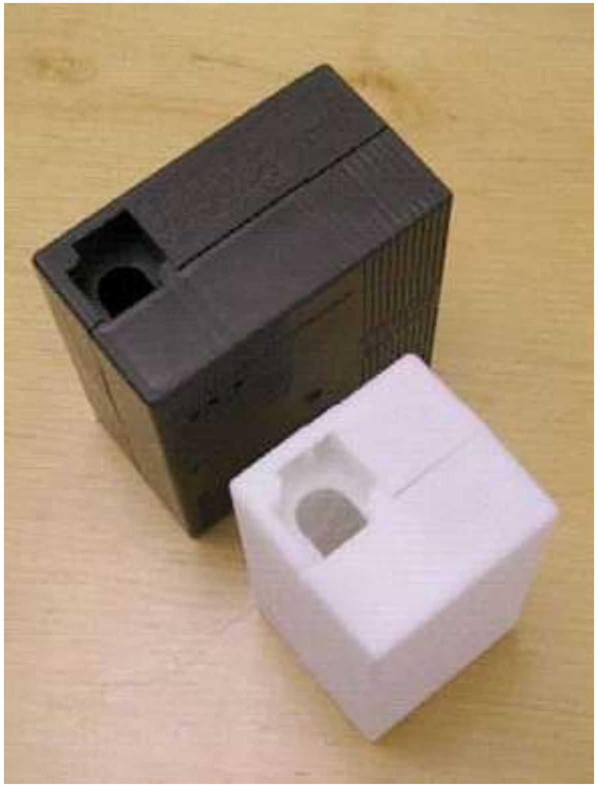
BA5590: 200 Wh, 2.2 lbs, $Li\text{-}SO_2$

BA5390: 300 Wh, 2.9 lbs, $Li\text{-}MnO_2$

Target:

1) 400 Wh, 2.2 lbs in same footprint
2) 200 Wh, 1.1 lbs in half size

400 Wh/kg



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Chemistry Comparison

Comparison of D-cells with Different Chemistries

Lithium – Cathode Chemistry System	Theoretical specific capacity (mAh/g)	*Safety Concern*	*Specific power (W/kg)*	2A Discharge Capacity (Ah)	*Voltage Delay*	*Cost*
CF_x	864	**Safe**	~15	**15.5; 16.8**	Yes	**Very High**
$SOCl_2$	480	**Yes**	140	**7.0**	Yes	**Medium**
SO_2	418	**Yes**	680	**7.5**	Yes	**Low**
MnO_2	308	**Safe**	300	**10.5, 13**	No	**Low**
CF_x/MnO_2	308~864	**Safe**	15~300	**≥ 15**	No	**Medium**

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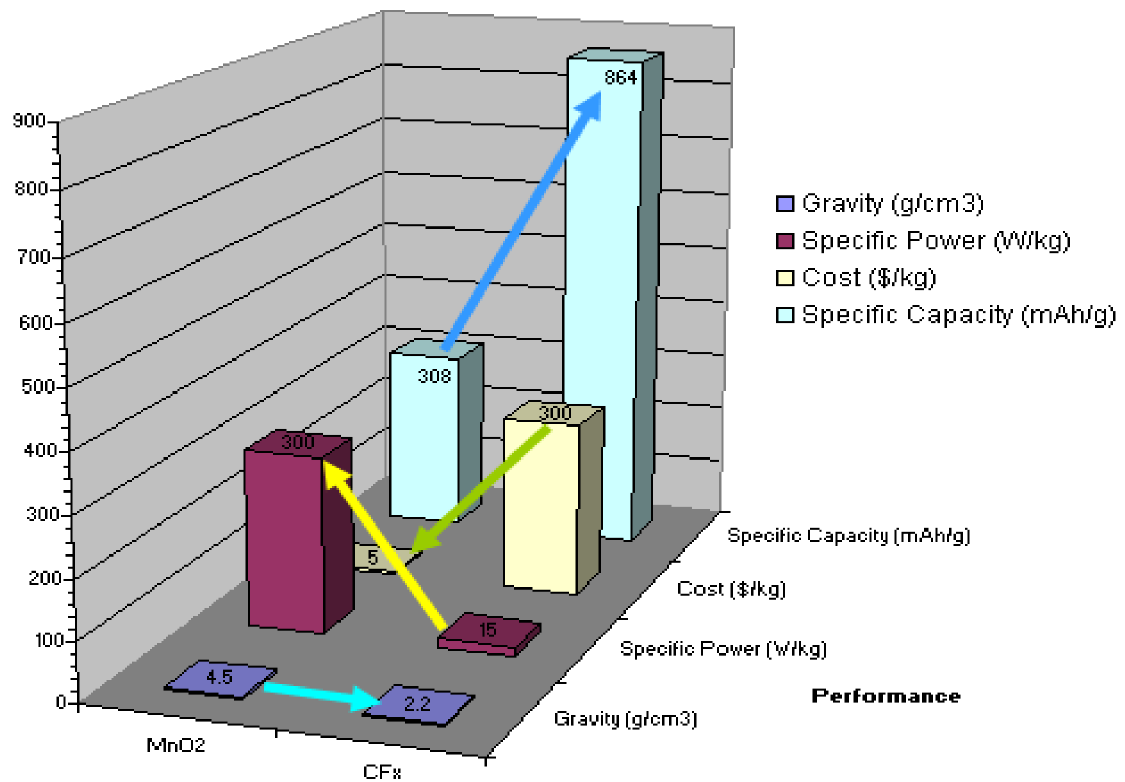
Design of Li-CF_x / MnO_2 Hybrid Chemistry



Hybrid Advantages

Flexibility of cell design
Lower self-discharge rate
Higher energy density

Lower overall thermal signature
Without voltage delay at LT
Relatively low cost

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Design Considerations

1) D-cell (34605)
2) Anode limited design
3) Cathode hybrid structure of CF_x and MnO_2
4) Thermal shutdown separator
5) Common components of UBI existing Li-MnO_2 production D-cell

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Phase I Li-CF_x/MnO_2 Hybrid D-cell

Goal was: Operating T range: -30^{o}C to +55^{o}C

1) Different anode

2) Different cathode with hybrid mixture of CF_x and MnO_2

3) All other parts as same as existing Ultralife Li-MnO_2 D-cell
   - Shutdown separator
   - Electrolyte
   - Cell enclosure

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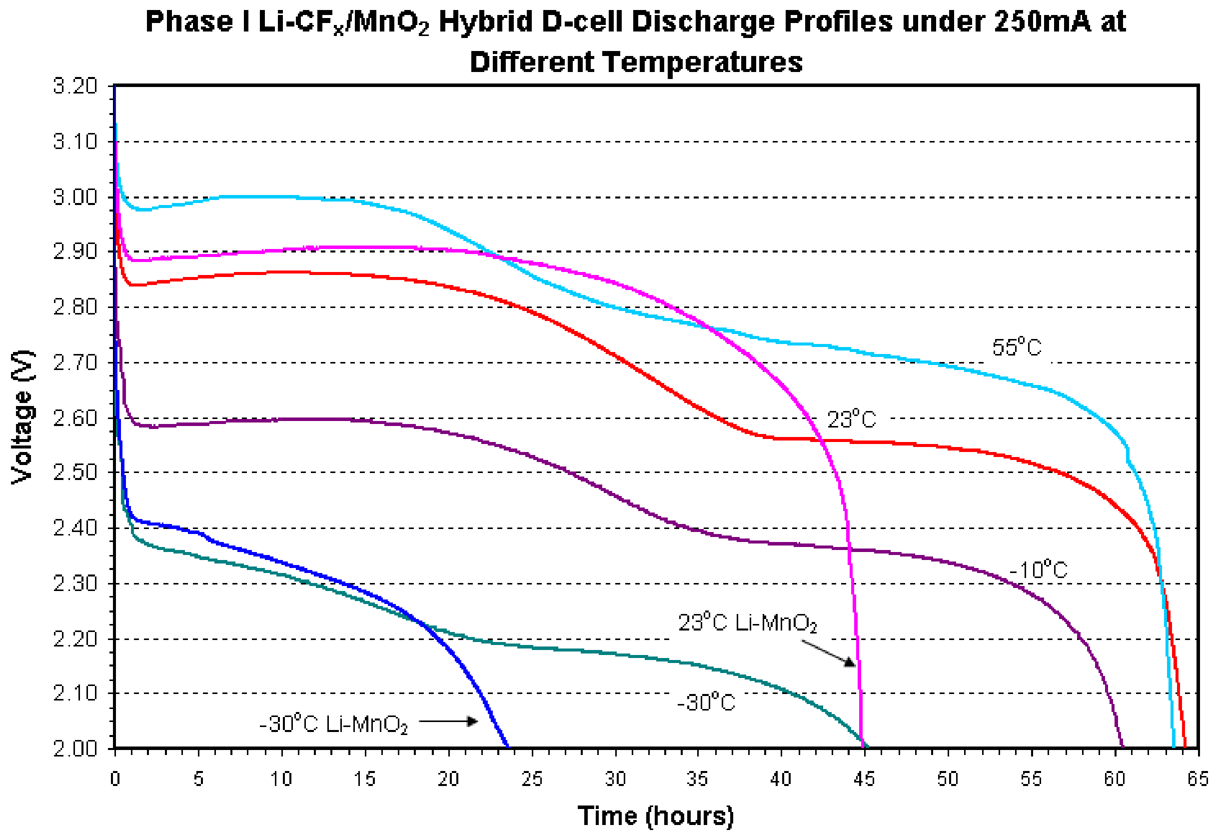
2011 Joint Service Power Expo
Myrtle Beach, SC, May 2-5, 2011

Phase I D-Cell Performance

Phase I Li-CF_x/MnO_2 hybrid D-cell discharge under 250mA constant current at 23°C, 55°C, -10°C and -30°C



Capacity to 2V cutoff

23°C: 16.06 Ah
55°C: 15.89 Ah
-10°C: 15.11 Ah
-30°C: 11.30 Ah

Li-MnO_2:
23°C: 11.20 Ah
-30°C: 5.90 Ah

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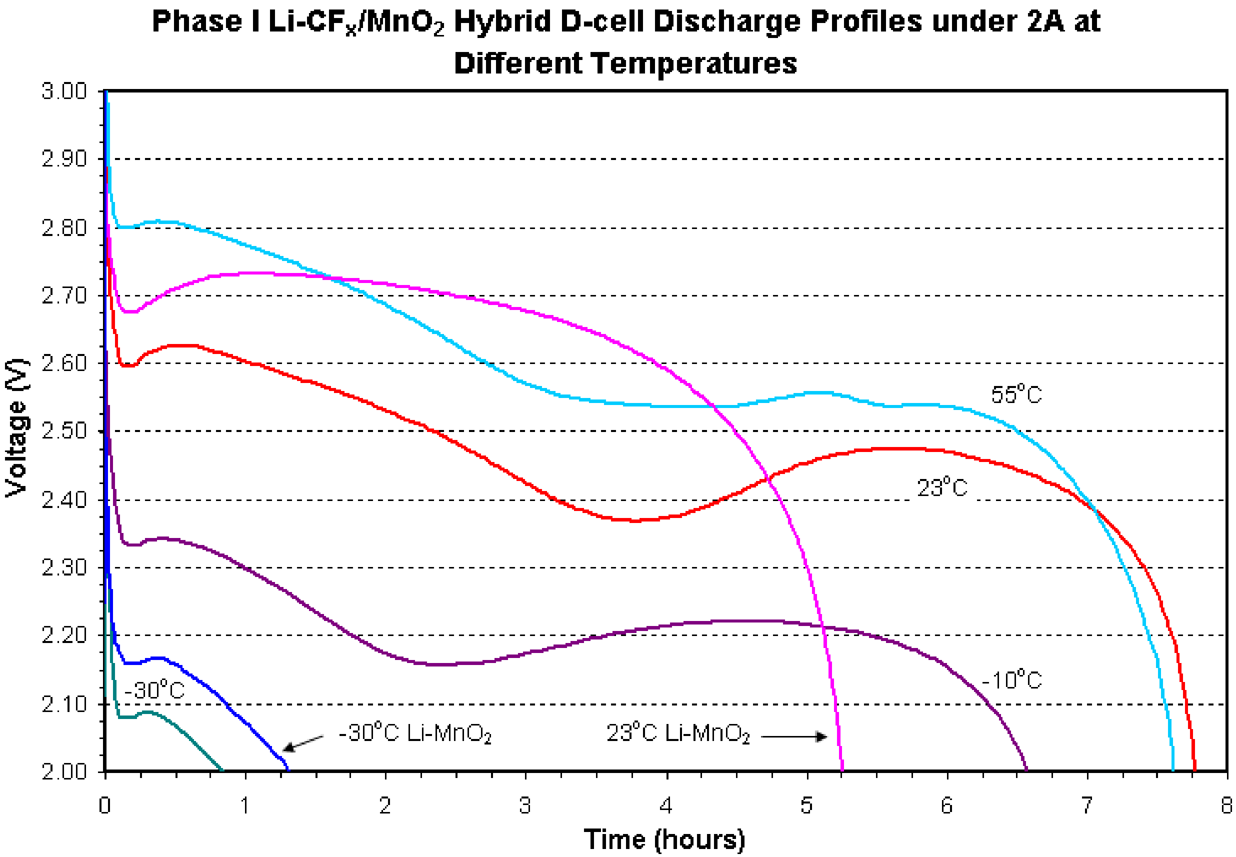
Phase I D-Cell Performance

Phase I Li-CF_x/MnO_2 hybrid D-cell discharge under 2 A constant current at 23°C, 55°C, -10°C and -30°C



Capacity to 2V cutoff

23°C: 15.50 Ah
55°C: 15.20 Ah
-10°C: 13.23 Ah
-30°C: 1.85 Ah

Li-MnO_2:
23°C: 10.51 Ah
-30°C: 2.63 Ah

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Phase I D-Cell Safety Performance

No	Name	Description	Result
1	UNTR-T1	Altitude	Pass
2	UNTR-T2	Thermal Test	Pass
3	UNTR-T3	Vibration	Pass
4	UNTR-T4	Shock	Pass
5	UNTR-T5	External Short Circuit	Pass
6	UNTR-T6	Impact	Pass
7	UNTR-T8	Forced Discharge	Pass
8	UL	Crush	Pass
9	SAR	Nail Penetration	Pass

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Phase II Li-CF_x/MnO_2 Hybrid D-cell

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Goal was: Operating T range: -40^{o}C to +100^oC

Worked on engineering for

1) Anode
2) Cathode using hybrid mixture of CF_x and MnO_2 with different particle size
3) Electrolyte
4) Separator

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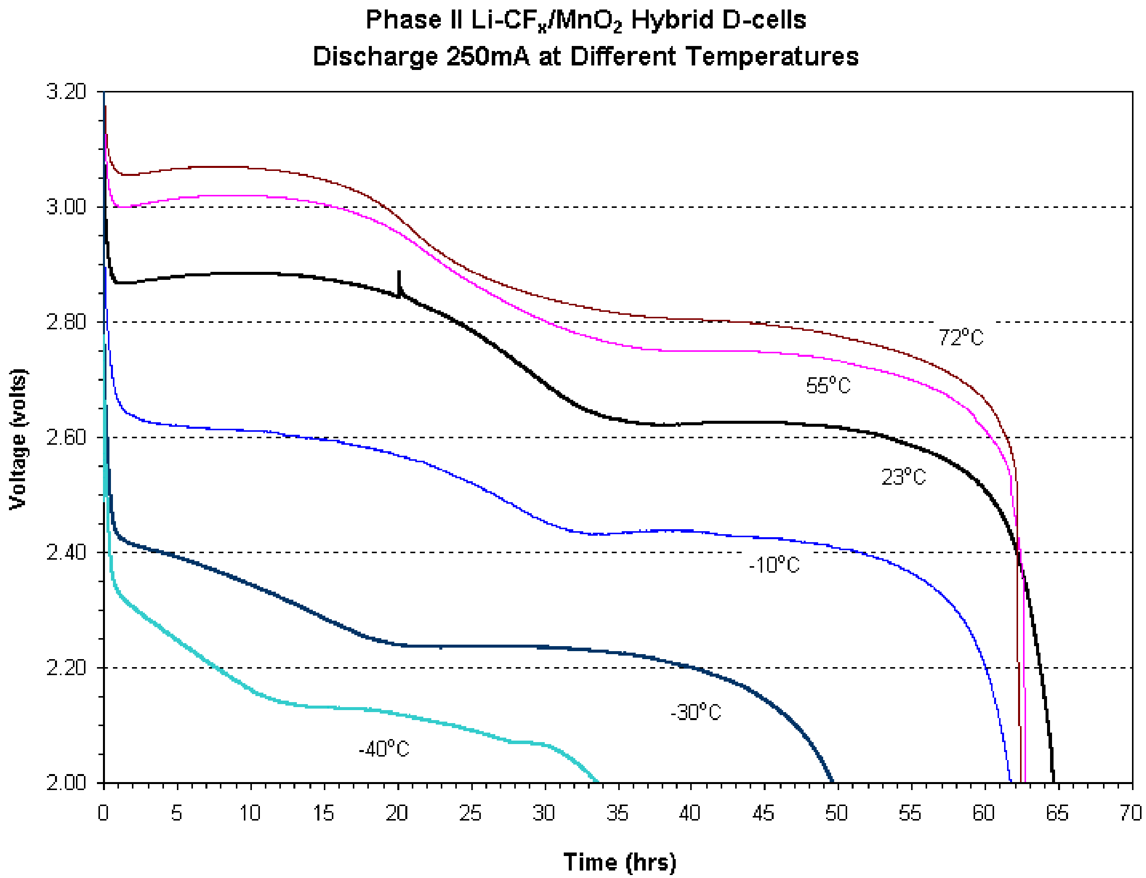
Phase II D-Cell Performance

Phase II Li-CF_x/MnO_2 hybrid D-cell discharge under 250mA constant current at 72°C, 55°C, 23°C, -10°C, -30°C and -40°C



Capacity to 2V cutoff

23°C: 16.05 Ah
55°C: 15.57 Ah
72°C: 15.67 Ah
-10°C: 15.13 Ah
-30°C: 12.16 Ah
-40°C: 8.15 Ah

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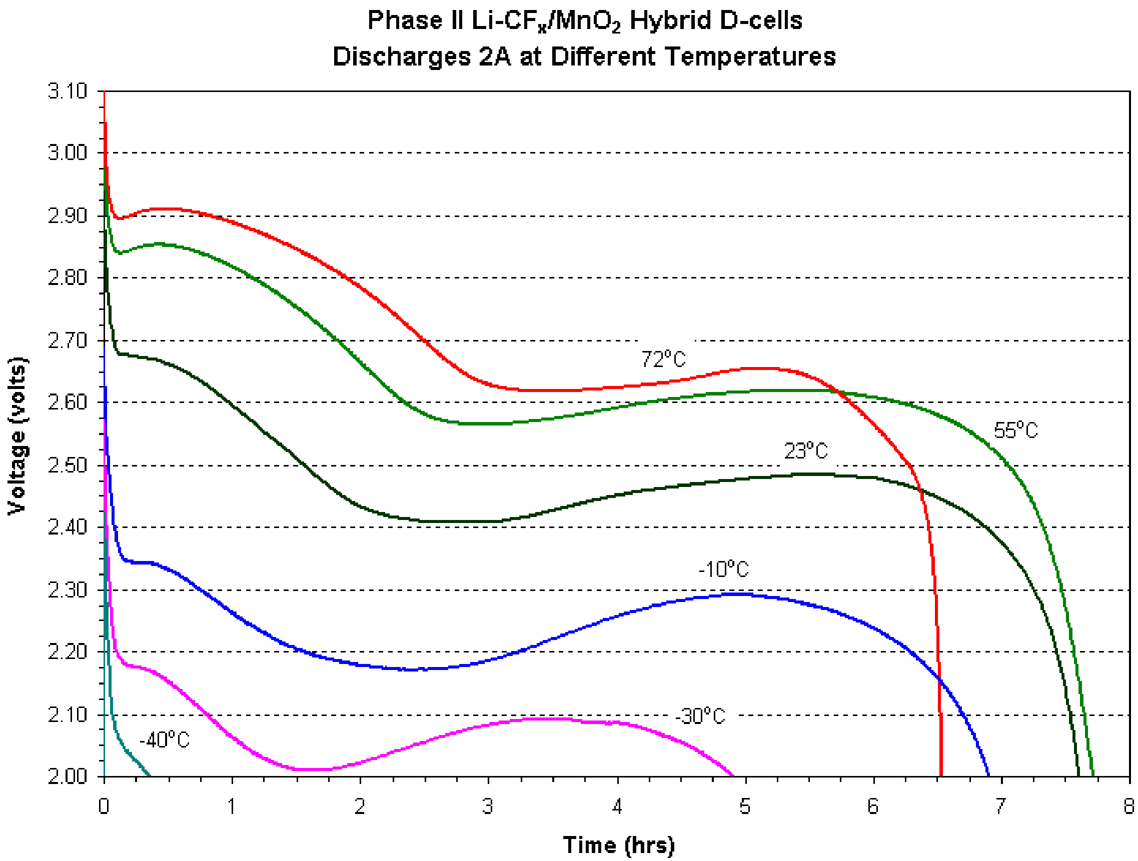
Phase II D-Cell Performance

Phase II Li-CF_x/MnO_2 hybrid D-cell discharge under 2 A constant current at 72^{o}C, 55^{o}C, 23^{o}C, -10^{o}C, -30^{o}C and -40^{o}C

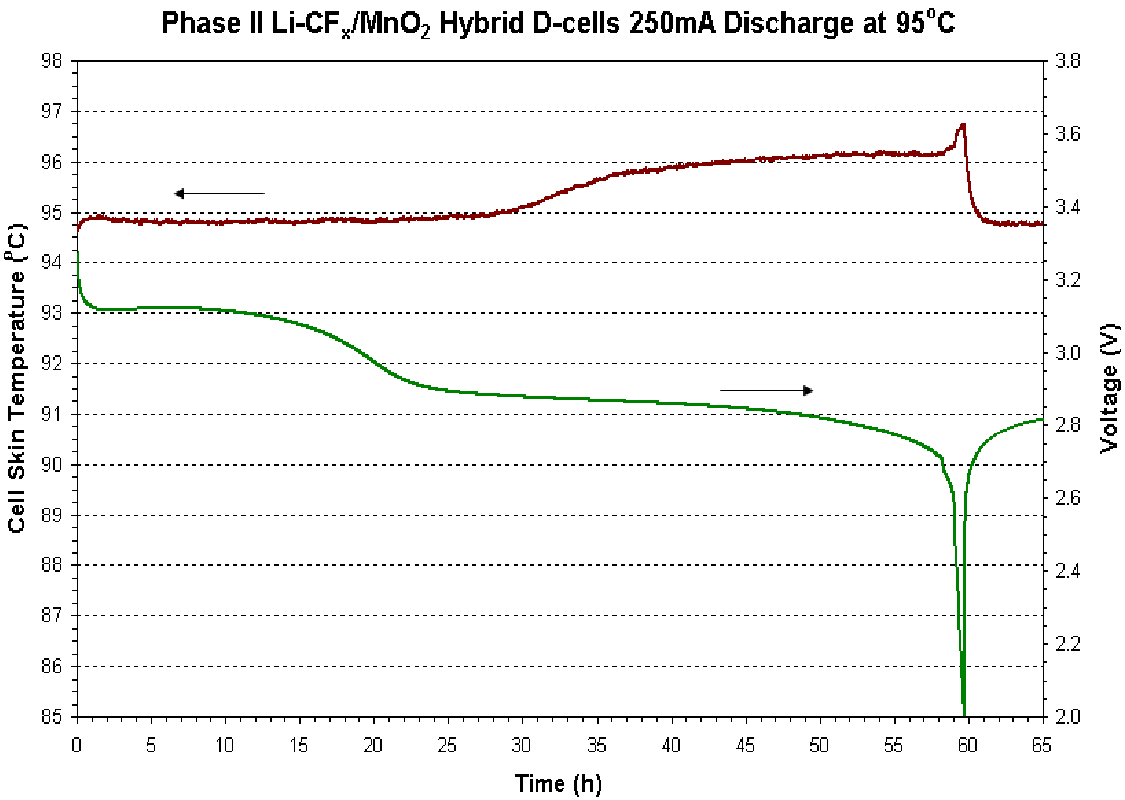


Capacity to 2V cutoff

23^{o}C: 15.13 Ah
55^{o}C: 15.36 Ah
72^{o}C: 12.66 Ah
-10^{o}C: 13.66 Ah
-30^{o}C: 9.80 Ah
-40^{o}C: 0.59 Ah

Phase II D-Cell Performance

Phase II Li-CF_x/MnO_2 hybrid D-cell discharge under 250mA constant current at 95°C



2V Cutoff

Capacity: 14.92 Ah
Energy: 43.59 Wh
Max. Skin T: 96.8°C

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Phase II D-Cell Safety Performance

No	Name	Description	Result
1	UNTR-T1	Altitude	Pass
2	UNTR-T2	Thermal Test	Pass
3	UNTR-T3	Vibration	Pass
4	UNTR-T4	Shock	Pass
5	UNTR-T5	External Short Circuit	Pass
6	UNTR-T6	Impact	Pass
7	UNTR-T8	Forced Discharge	Pass
8	UL	Crush	Pass
9	SAR	Nail Penetration	Pass

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Acceleration Testing for Shelf Life

Li-CF_x/MnO_2 hybrid D-cells (Phase I) discharge 250 mA after storage 50 days or 100 days at different acceleration temperatures

Equivalent storage terms at 23^{o}C by that at acceleration temperatures	Capacity to 2V cutoff (Ah)	Percentage of capacity remain	Self-discharge rate
100 days at 23^{o}C	15.44	100%	0
5 years at 23^{o}C	15.32	99%	0.4%/year
10 years at 23^{o}C	14.45	94%	0.6%/year
20 years at 23^{o}C	14.15	92%	0.4%/year

Initial Shelf Life Testing

92% of capacity remains

for 20 years by acceleration testing

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Summary

Li-CF_x/MnO_2 Hybrid D-cell

- 15 Ah under 2A constant discharge for both Phase I & Phase II
- Specific energy density increases 47% more than Li-MnO_2 D-cell

❑ Pass UNTR and other SAR tests for both Phase I & Phase II

- Phase I has operating temperature range from -30°C to 55°C
- Phase II has operating temperature range from -40°C to 72°C

❑ Initial shelf life tests indicate up to 20 years with 92% capacity remain

- Ready to be used for different formats of military batteries, such as xx47, half size xx90, full size xx90 and large size xx90, some in progress

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Acknowledgement

Li-CF_x/MnO_2 Hybrid D-cell Development Is Also Under Support of Contract W15P7T-05-D-C002/002 With US Army CERDEC

- Special Thanks to
Mr. Michael Brundage & Mr. Chris Hurley of US Army RDECOM

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Thank You for Your Attention

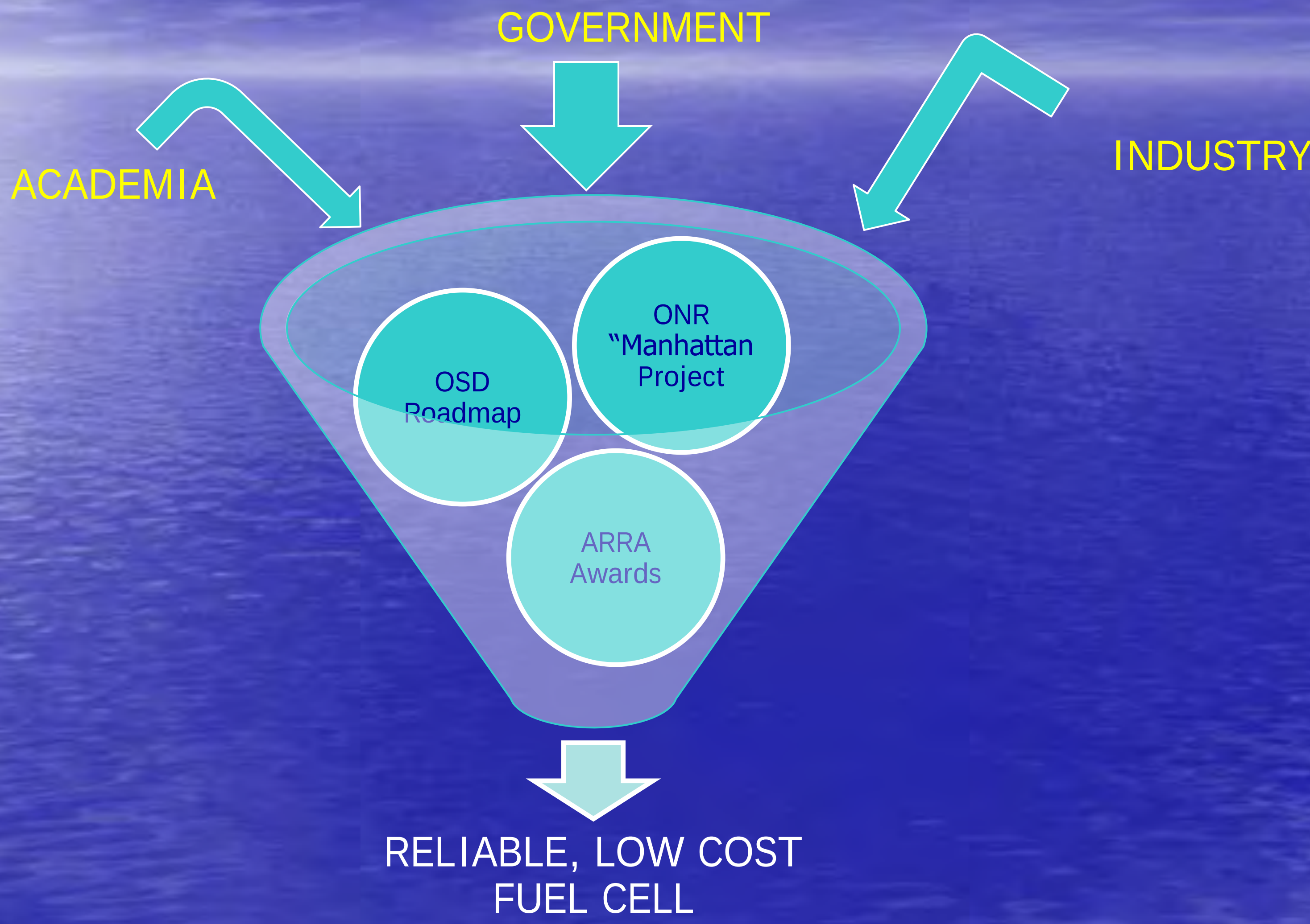
Fuel Cell Technology Working Group

FCTWG

FCTWG

- Chartered by DoD Project Manager, Mobile Electric Power PM MMEP
- Multiple Government Agency Participation
- Tasks
  - Identify Military Requirements
  - Share information
  - Develop transition plans
  - Develop an investment strategy

Reaching a Critical Mass



Technology Road mapping Effort

- Part of the DoD Power Sources Technology Roadmap that was previously developed
  - Roadmap requested by the Manufacturing Technology (ManTech) Office at OSD
  - Focused on Batteries
  - Touched on small fuel cells
  - The "Power Sources Technology Roadmap" is available on a secure web site—for access:
    - Available to government employees and Companies with government contracts
    - Must fill out form
    - Contact jag@tiburonassociates for access form

Technology Road mapping Effort

Purpose:

- Identify the priority technology needs of DoD power source systems:
  - Near term (1-3 years) Fuel Cells
  - Mid term (4-6 years) Fuel Cells
- Roadmap establishes a needed foundation for further planning of potential R&D projects

Goals of the Roadmap

- Strategic/high level overview of military power sources technology development
- Tool for comparing current and future military power source capabilities versus WarFighter requirements
- Identify a path for resolving shortfalls

Roadmap Content

- Fuel Cell Roadmap covers 3 ranges:
  - Section 6.1: Soldier-carried power and sensors & Man-portable power (1W-1kW) – Completed / Needs refreshing
  - Section 6.2: Mobile Power (1kW-100kW) - Next
  - Section 6.3: Stationary Systems (>100kW)
  - Section 6.4: Fuel Reforming

Roadmap Content (cont'd)

- The Roadmap addresses various Fuel Cell types as well as Reformers:
  - Direct Methanol Fuel Cells (DMFC)
  - Reformed Methanol Fuel Cells (RMFC)
  - Chemical Hydrides with PEM
  - Proton Exchange Membrane (PEM)
  - Solid Oxide Fuel Cells (SOFC)
  - Molten Carbonate Fuel Cell (MCFC)

The "Notional" Process

- Research: Perform literature search on current programs and vendors
  - What are the various power ranges and fuel cell types?
- Discussions: Discuss needs, barriers, etc with DoD/Industry experts
- Perform industry inquiry
  - Identify the key industry resources
- Assemble table and data
- Team with FCTWG to generate report
- Socialize report for comments
- Publish report

Your Participation

- Keeps you abreast of roadmap initiatives
- Assures your technology is properly captured
- Expands the audience for your technology
- Identifies your technology in terms of military requirements
- May influence DoD Transition Plans
- May influence DoD Technology investment plans

Help Needed

Research

- Identify key Industry Fuel Cell developers and points of contact.

Discussions

- Provide inputs for Fuel Cell Types, Advantage and Disadvantages, Projected Applications.
- Define applications versus fuel cell type versus power range.

Inquiry

- Provide inputs to the parameter matrices considering fuel cell type, application, power ranges.
- Provide inputs for technology investments

Socialize

- Review the draft Fuel Cell Roadmap

If you can assist please provide a point of contact from your organization, organization name, what inputs you can provide

To Become a voice in the Process

Contact

Frank Sokolowski, Industrial Engineer

Defense Contract Management Agency (DCMA), Industrial Analysis Center (IAC), Systems Analysis Team

Phone: 215-737-0588, DSN 444-0588

E-Mail: francis.sokolowski@dcma.mil

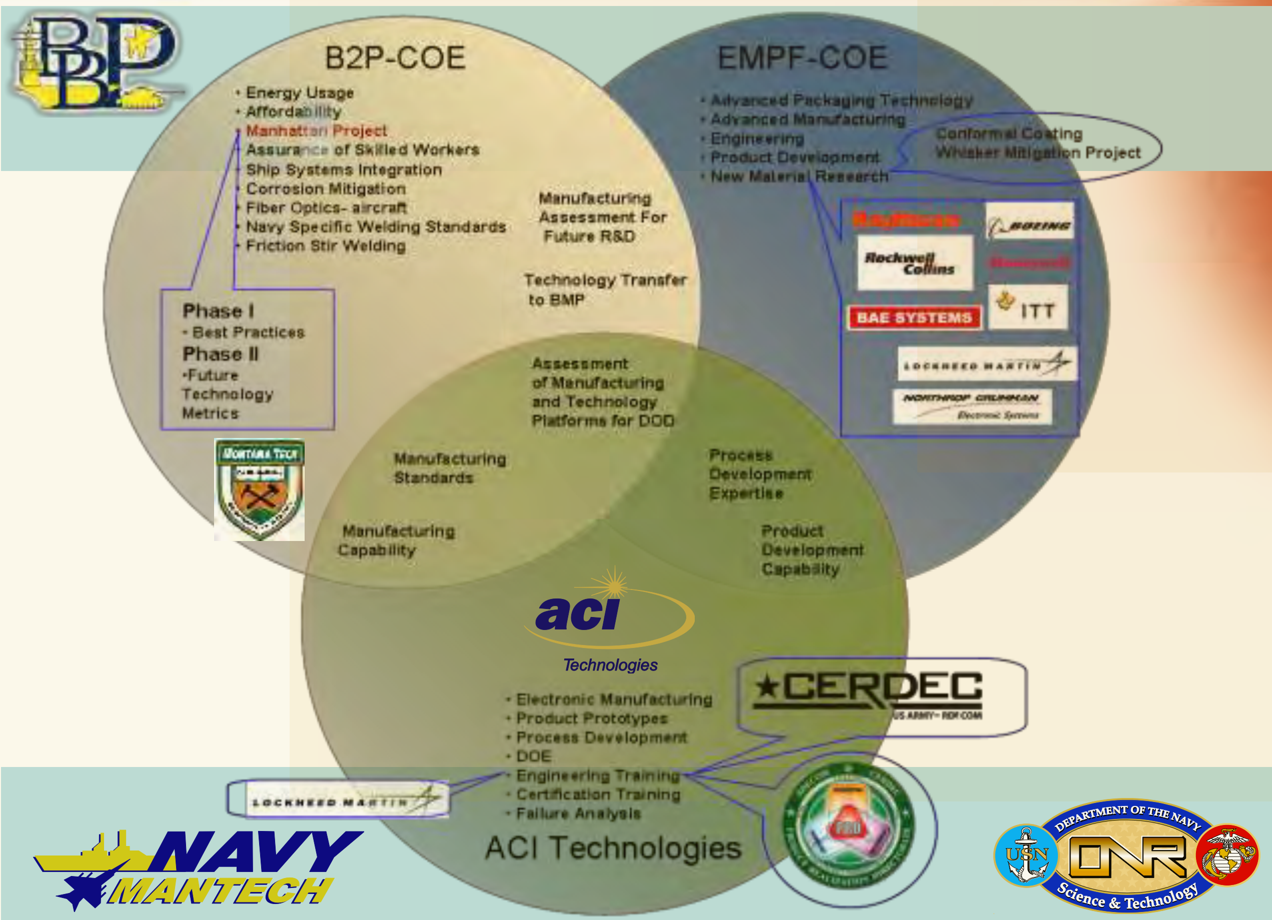
Questions?

Questions and Comments?

Manufacturing Fuel Cell Manhattan Project

Presented by
Carmine Meola
Rebecca Morris

MFCMP Project Sponsors



Example Special Projects within the B2PCOE

- Energy Usage – Ship Yard Cost Reduction
- Lead Free – Manhattan Project (DOD Leverage)
- Best Practices for Assurance of Skilled Workers
- Best Practices in Ship System Integration
- Advanced Shipbuilding Affordability Technologies
- *Manufacturing Fuel Cell Manhattan Project*

Manhattan Manufacturing Fuel Cell Project

- MFCMP Phase 2
- Location: Butte, MT
- Dates
  - Polymer and BOP Session: March 15 – 20, 2011
  - Ceramic Fuel Cell Session: March 17 – 22, 2011
  - Joint Session Days: March 17 – 20, 2011
  - Leadership Wrap Up: March 23, 2011

Manufacturing Fuel Cell Project

Program Leaders

- Rebecca Clayton – ONR

- Carmine Meola – ACI
- Rebecca Morris – ACI
- Mark Shinners – ACI

- Randy Hiebert – MTT
- Robert Hyatt – MTT
- Jay McCloskey – MTT
- Brian Park – MTT
- Ray Rogers - MTT

Technical Leaders

- Mark Cervi – NSWC Philadelphia
- John Christensen – Consultant
- Marc Gietter – CERDEC
- Leo Grassilli – ONR
- Shailesh Shah – CERDEC
- Mike Ulsh – NREL / DOE

Manufacturing Fuel Cell Project

Participants

- Joe Bonadies – Delphi Corp.
- David Carter – Argonne
- Mark Cervi – GDIT / NSWC
- Paul Chalmers – Hydrogenics
- John Christensen - Consultant
- Aaron Crumm – AMI
- William Ernst – Consultant
- Matt Fay – General Motors
- Marc Gietter – CERDEC
- Leo Grassilli – ONR
- Pat Hearn - Ballard
- Dennis Kountz – DuPont
- Rebecca Morris – ACI
- Randy Petri – Versa
- Joe Poshusta – Protonex
- Jolyon Rawson - Acumentrics
- Steve Rock – RPI
- Kathryn Rutter - Ballard
- Shailesh Shah – CERDEC
- Duarte Sousa – Ballard
- Eric Stanfield – NIST
- Matt Steinbroner – Consultant
- Scott Swartz – NexTech
- John Trocciola – Consultant
- Mike Ulsh – NREL / DOE
- Doug Wheeler – DJW Tech

Manufacturing Fuel Cell Project

Objectives , Benefits, and Applications

Objectives Completed

B2PCOE
Montana Tech
SME's

↔

Industry
Academia
Government
FC Consortiums

- Objectives Phase 1 – October 2010
  - √ Identify manufacturing cost drivers to achieve affordability
  - √ Identify best practices in fuel cell manufacturing technology
  - √ Identify manufacturing technology gaps

Manufacturing Fuel Cell Project

Deliverables Phase 2 – March 2011

Manufacturing Roadmap

- **Projects to resolve the gaps**
- **Schedule a strategy for effective investment**
  - **Sequence Projects**
  - **Prioritize Projects**
  - **Projects that can benefit all**
- **Manufacturing Fuel Cell Publication: Oct. 2011**

Navy Benefits

Why the Navy Cares

- **Reduce logistics and financial footprints for delivering energy**
- **Increase fuel efficiencies**
- **Modularity for distributed power systems**
- **Supplemental Power**
- **Reduce ship signatures**
  - **Lower thermal signatures**
  - **Lower audible noise**
- **Low maintenance when compared to diesel generators**
- **Lower hydrocarbon emissions**
- **Lower SO_2 and NO_2 emissions**

Manufacturing Fuel Cell Project Taxonomy

- Fuel Cells
  - Polymer
    - MEA
      - Ionomer & Membrane
      - Gas Diffusion Layer
      - Ink Mixing & Delivery
      - Catalyst Coated Membrane
      - MEA Low Temp PEM
      - MEA High Temp PEM
    - BOS
      - PEM Bi-Polar Plate
  - Ceramic
    - Planar
      - Stack Assem Comm & Testing
      - Stack Separator Plate
      - Inspection
      - Seals
    - Tubular
      - Cells
      - Current Collector
      - Insulation
  - BOP
    - Reactant Mngt
    - Power Mngt
    - Controls & Software
    - Mech & Package Ruggedization
    - Thermal Mngt
    - Inspection

Manufacturing Fuel Cell Project

DOD Applications That May Benefit

Target Applications

Soldier Power

Unmanned UAV

Emergency Power

Tactical APUs

Aircraft APUs

Shipboard APUs

Material Handling

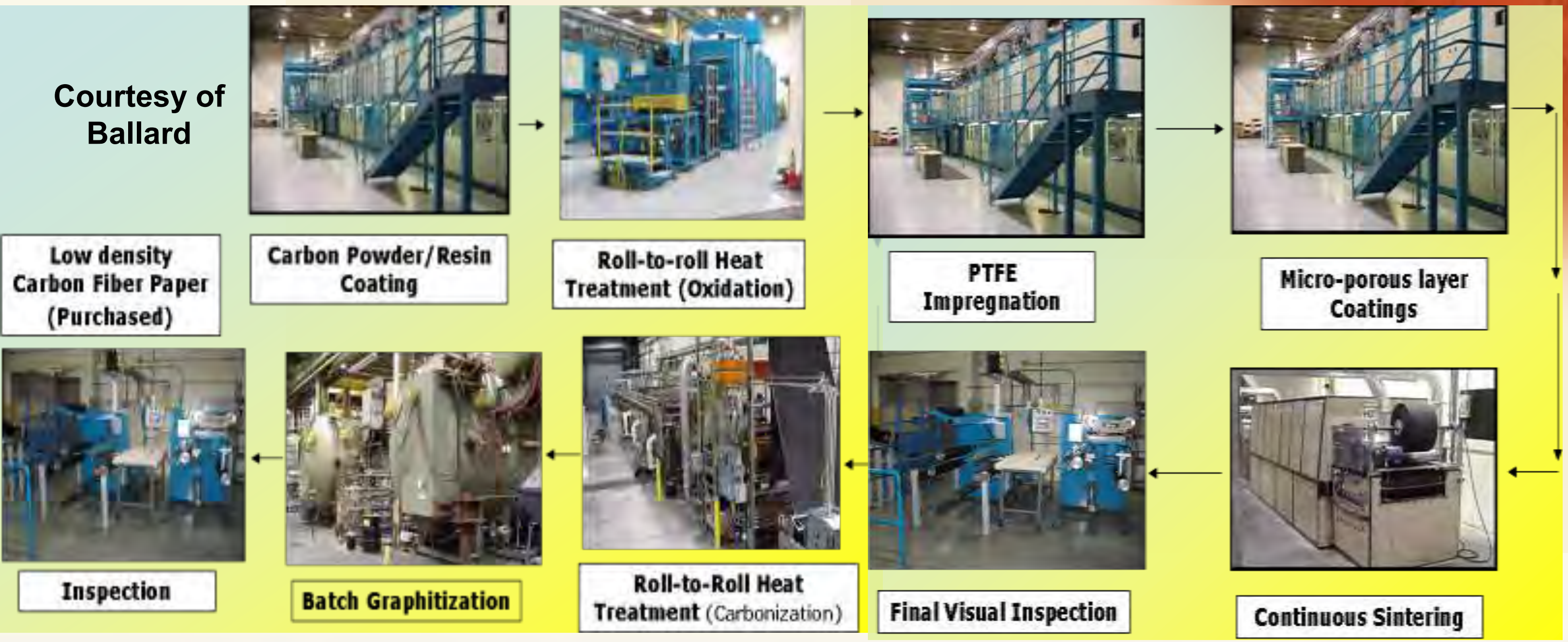
Distributed Stationary Power

System Power in Watts

1	10	100	1000	10000	100000	1000000

Manufacturing Fuel Cell Project

Cost Drivers
For Polymer Fuel Cells (MEA, BP, BOP)

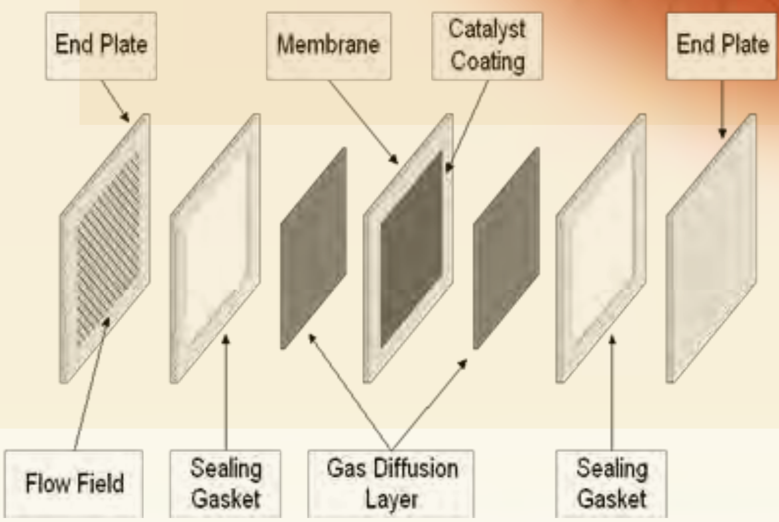


Polymer Membrane Fuel Cell Session

Key Cost Drivers For Membrane Electrode Assembly (MEA)

- Electrode
- Pt group catalyst
- Membrane
- GDL / Seals
- Assembly

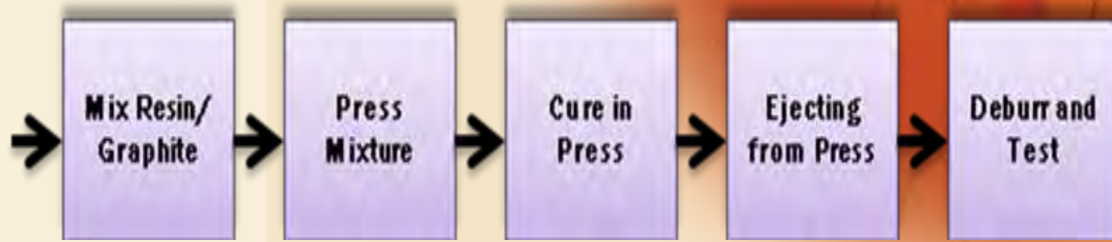
Fuel Cell Components



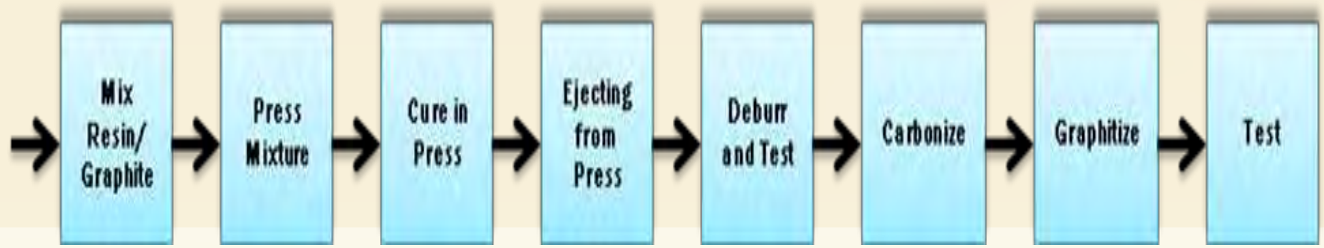
Key Cost Drivers For PEM Bipolar Plates

- Bipolar Plate
- Labor
- End Plate
- Stack Sealing
- Hardware
- Packaging

Low Temp BP Manufacturing Process



High Temp BP Manufacturing Process



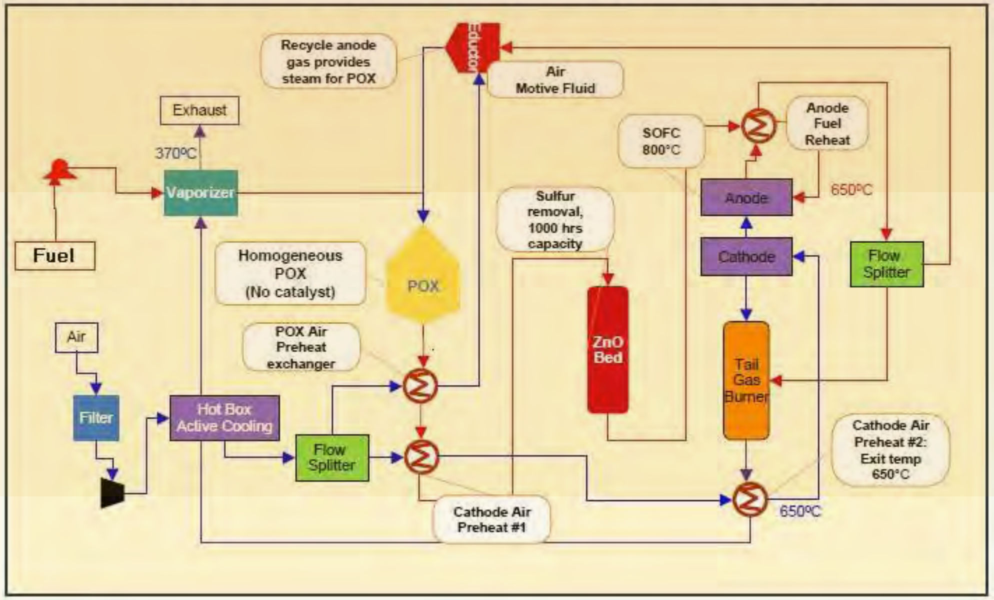
BOP for Polymer & Ceramic Fuel Cell Session

Key Cost Drivers BOP

- Stack
- ATR / Reactant Management
- Mechanicals Packaging
- Controls
- Thermal Management
- Power Conditioning / Management
- Balance of Hot Zone

Example of SOFC Heat Removal

The SOFC system flow diagram shows that equipment for heat removal (and recovery) and fluid movement plays a critical role in the system.



Manufacturing Fuel Cell Project

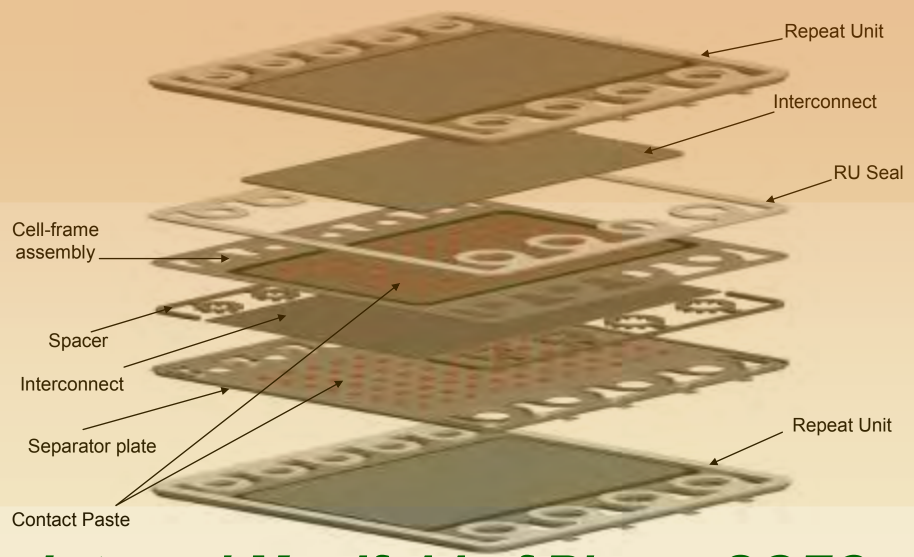
Cost Drivers
For Ceramic Fuel Cells (Planar, Tubular)

Ceramic Membrane Fuel Cell Session

Key Cost Drivers For Planar Designs

- Planar Cells
- Separator Plates
- Seals
- Manifolds
- Compression Means
- Contact Layers
- Terminal Conductor Plates

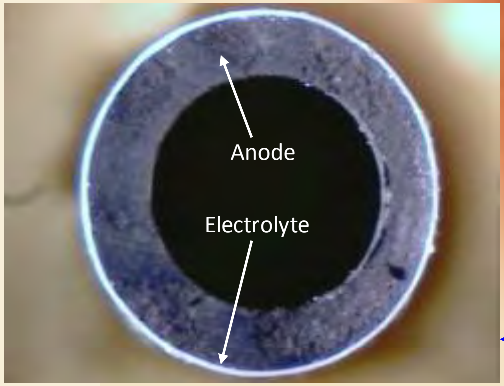
Repeat Unit Exploded View



Internal Manifold of Planar SOFC

Key Cost Drivers For Tubular Designs

- Recuperator
- Current Collection
- Cell
- Insulation
- Burner
- Reforming
- Seals
- Mechanical Enclosure
- Manifold



Tubular SOFC

Coil Winding for Current Collection

Manufacturing Fuel Cell Project

Path Forward

aci BBP NAVY MANTECH ONR CAMP MontanaTech THE UNIVERSITY OF MONTANA

Manufacturing Technology Gap Categories

Manufacturing areas where projects have been Identified to resolve gaps

- **Production Automation**
- **Production Material**
- **QC during Manufacturing**
- **QC for Product**
- **BOP Hardware**
- **BOP Performance**
- **Materials**
- **Design Performance**
- **Design Controls**

Total of 70 Gaps Identified → **About 32 Projects recommended to Address Cost Savings**

Polymer Projects

- Manufacturing cost trade-off analysis on raw material
- Reduce PT loading to 0.15 g/m^2
- Develop patch coating
- Direct coated layers on membranes
- Develop paper GDL for HTPEM
- Develop continuous mixing process
- Improve ink mixing process
- Direct coating layers on GDL

Polymer Projects Continued

- Process development for mitigation from discrete to continuous
- Develop X-Y gradients H_2 rich inlets to H_2 depleted outlets
- Reduce critical design requirements and defect rejection criteria
- Development of a low cost resin for HTPEM bipolar plates
- Measurement of vapor pressure of phosphoric acid over HTPEM
- Utilize metallic bipolar plates for LTPEM

Ceramic Projects

- Protective coatings for metallic stack components
- Defect free electrolyte layer
- Manufacturing of low-cost , high-efficiency insulation packages
- Solid oxide fuel cells stack manufacturing ,commission and testing
- Net shape manufacturing of stack methods
- Solid oxide fuel cell automated assembly
- Automation of current collection application for tubular SOFC

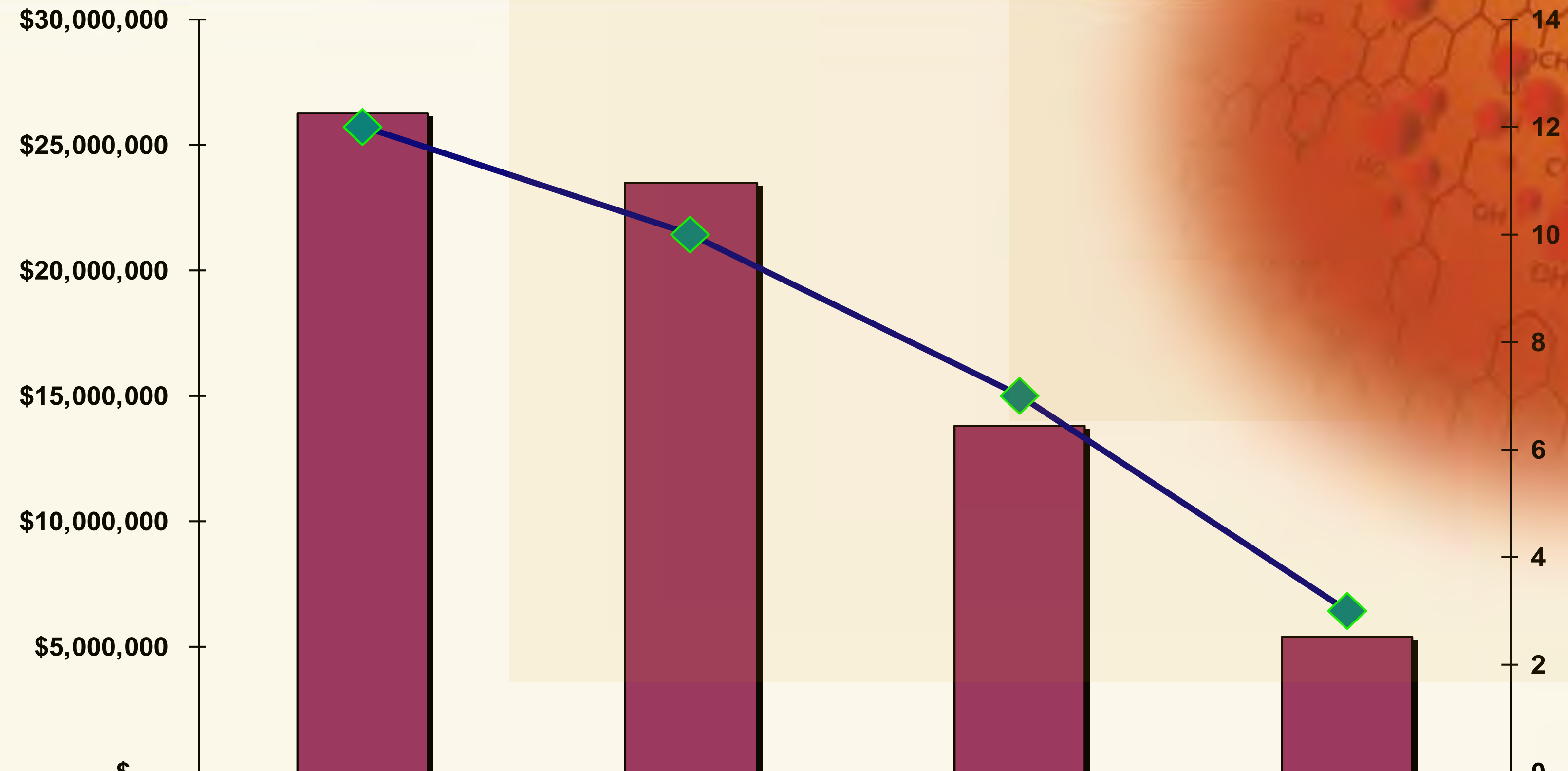
BOP Projects

- Manufacturing of low-cost, high-efficiency heat exchangers
- Liquid metering pumps for sub kilowatt reformed based FC systems
- Best practices for manufacturing anode gas movement devices
- Manufacturing improvements for fuel cell humidification systems
- Specification analysis for fuel cell power systems
- Liquid flow meter for sub-kilowatt reformer based FC systems

Fuel Processing Projects

- Improve Sulfur Sensor for logistics fuels
- Improve desulfurization of JP-8, JP-5, F76

FC Area vs Costs by Projects



	Polymer	Ceramic	BOP	FP
Cost	$26,276,694	$23,456,956	$13,821,200	$5,375,185
Projects	12	10	7	3

Recommendations

- Implement discrete projects that will have an immediate benefit to reducing fuel cell cost
- Establish CALCE or SAMETAC type consortium for fuel cells
- Recommend consortium specific projects
- Establish manufacturing working group
- Propose a phase III power management and integration session
- Propose a plan to the ONR for an alternative energy COE for Naval Platforms

Discrete Fuel Cell Projects

- Application specific - will have cost benefit to Navy and other DOD programs
- Immediate benefits < 3 yrs
- Unique to manufacturer – proprietary to a degree - will result in cost reduction of fuel cell systems

Consortium Projects

- Addressing (DoD) specification “Feature Creep”
- Cross-cutting development of automation capabilities for cells and stacks
- Understanding critical-to-quality parameters for ceramic powder specification and enhancing supply chain leverage
- Developing transfer functions for the linkages between manufacturing variability and cell performance/durability
- Developing solutions for the transition from solvent- to aqueous- based processing
- Developing methods (protocols and transfer functions) and support equipment to enable accelerated lifetime testing for SOFC cells and stacks

Consortium Benefits

- Establish government-industry consortia to address over-arching issues
- Not cost effective for individual companies to address themselves
- Work would benefit all industry
- Supports the competitiveness of the North American fuel cell manufacturing base
- Benefit from capabilities across federal agency labs and academia
- Would incorporate non-disclosure agreements where necessary

Manufacturing Working Group

- Continue collaboration and „esprit de corps" developed in the MFCMP
- Forum for labs / academia to report on new developments related to manufacturing
- Capture manufacturing needs and issues for DoD and DOE consumption and action
- Group to be informed on DoD application requirements and developments by DoD fuel cell TWG
- Group possibly hosted by FCHEA or NDIA Manufacturing Division

Power Management and Integration

- FC power management issues were discussed in Phase I but not addressed fully
- Integration of FC power management into DoD deployed systems needs to be developed (e.g., integration with other renewables, and hybrid systems)

Path Forward

- ONR has begun funding efforts of MFCMP recommendations
- MFCMP team will brief ONR and other DoD PMs on the findings and potential cost savings to secure additional funding
- Propose a development of an alternative energy center of excellence

Q&A

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http://www.aciusa.org
http://www.navyb2pcoe.org

Manufacturing Fuel Cell Manhattan Project

Back Up Slides

Fuel Cell Project Scope

MFCMP Scope:

Power ranges

- <0.5 kW (man portable / man wearable)
- 0.5 kW< Power range < 10kW (mobile power)

Fuels: Hydrogen and reformed hydro-carbons

- Packaged Fuels < 0.5 kW
  - Near term solution
  - Move through the supply chain like batteries
  - Examples: methanol, ethanol, propane, butane, chemical hydrides, hydrogen
- Logistics Fuels > 0.5 kW (long term solution)
  - Long Term Solution
  - Examples: JP-8, diesel

Applications

Navy Applications

- Unmanned Vehicles (Unmanned undersea vehicles, UAV, UGV)
- Submarine Emergency Power

- Ship Service (0.5-2.0 MW)
- CHP base housing / apartments
- CHP PX, Fire Station
- Material Handling/Fork Lifts (DLA)
- Automotive (Camp Pendleton, 6 ea GM vehicles planned)

Applications

ARMY Applications

- Soldier Portable Power
- Battery Charging
- Power Source (hybrid configurations)
- Remote Sensors
- UAVs / UGVs
- Vehicle Auxiliary Power
- Base Camp Power

USMC Applications

- Man-portable Charger, CERDEC, 250 W
- Portable Power, TARDEC
- Tactical Wheeled Vehicle Onboard Power, CAASCOM, 5-10 kW

aci NAVY MANTECH CAMP MontanaTech THE UNIVERSITY OF MONTANA

Polymer Membrane Fuel Cell Session

Major Key Manufacturing Needs Identified for MEA

- Ink mixing to coating operation - minimize time
- Ink processing through continuous methods
- Correlating QC measurements to requirements
  - What tests are necessary?
- Need on-line /real time QC testing techniques
- Raw material traceability
- Relate existing metrics and to downstream product requirements
- Maximum utilization of catalyst
- High production volumes will need quick turnaround testing of subsystems

Polymer Membrane Fuel Cell Session

Key Manufacturing Needs Identified for Bi-Polar Plates

- For LTPEM the bipolar plates need the use of alternate graphite resin compositions to facilitate easier molding
- Testing and evaluating critical design parameters of bipolar plates (BP)
- A low cost metallic plate would use more conventional manufacturing process- thus lowering cost
- For HTPEM it is critical to reduce multiple heat treatments for cost reduction
- For HTPEM find a method to employ air cooling process to replace high water pressure /steam mixture

BOP for Polymer & Ceramic Fuel Cell Session

Key BOP Manufacturing Needs Identified

- **Autothermal Reformers (ATR) need to operate at temperatures near or below 800°C to eliminate the use of high cost metal alloys; the latest ATR designs & catalyst appear to have resolved this issue**
- **Catalytic Partial Oxidation Reformers susceptible to coking issues- requiring insulative housing and filter systems**
- **The CO_2 and CO removal process are not designed to suit small scale reformate clean-up**
- **Water management systems need to utilize more efficient designs to reduce weight and cost over the present membrane modules**

BOP for Polymer & Ceramic Fuel Cell Session

Balance of Plant - cont

- **Commercial fuel and oxidant delivery as well as air supply components generally do not satisfy the specifications for the critical parameters for fuel cell applications**
- **Heat exchangers also fall into this category**
- **When feasible, safety and control systems should transition to software based systems**
- **Alternate plate fin exchangers may provide a more cost effective solution, providing low material and manufacturing costs**

Ceramic Membrane Fuel Cell Session

Key Planar Manufacturing Needs Identified

- Assurance of stack quality is labor intensive requiring a more mechanized approach to assure consistency at higher volumes
- Optimization by the means of decoupling QC process would increase throughput and reduce cycle time
- There is little industry standardization for stacks. The Capital equipment to produce larger volumes is a significant cost
- An accelerated testing strategy needs to be developed for stacking as well as BOP. i.e. thermal cycling, load cycling, etc for lifetime prediction
- Optimization of coating and material selection for end plates, bipolar plates and flow field is needed.
- There is a lot of material waste in seals. A dispensing or molding process for forming seals would reduce cost

Ceramic Fuel Cell Session

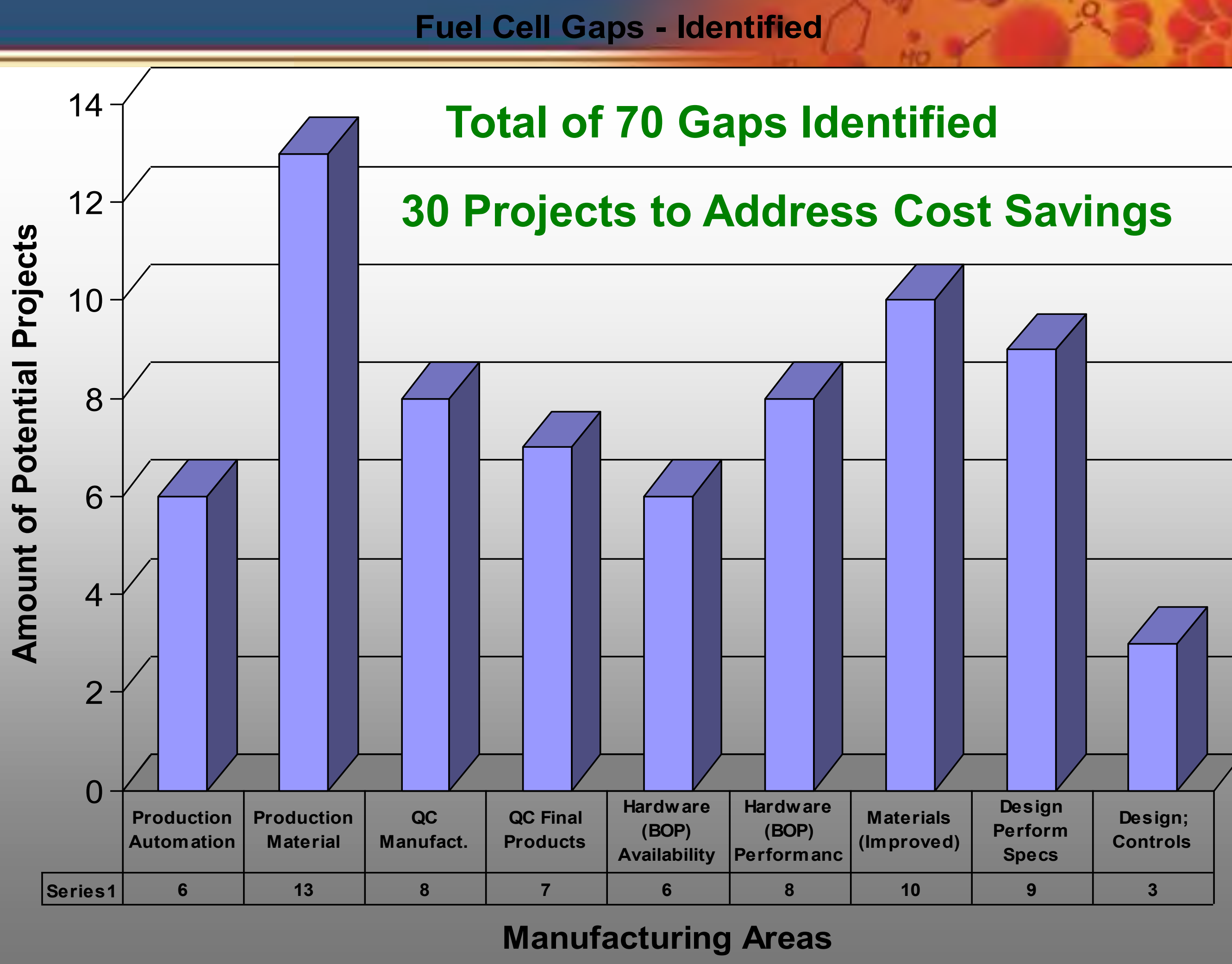
Key Manufacturing Needs Identified

- Dimensional tolerances of tubes difficult with high aspect ratio tube with thin walls
- The application of a uniform electrolyte layer on the tube is challenging and is prone to yield loss
- Current collector process needs to be automated with high rate wire winding and tie off
- Current QC test for both planar and tubular FCs require in-process testing prior to stack assembly to reduce cost. This includes analysis of powders batches, slurries, tape cast, green tape, electrolytes, etc.
- The relevant tests must be identified that will affect the quality of the overall stack

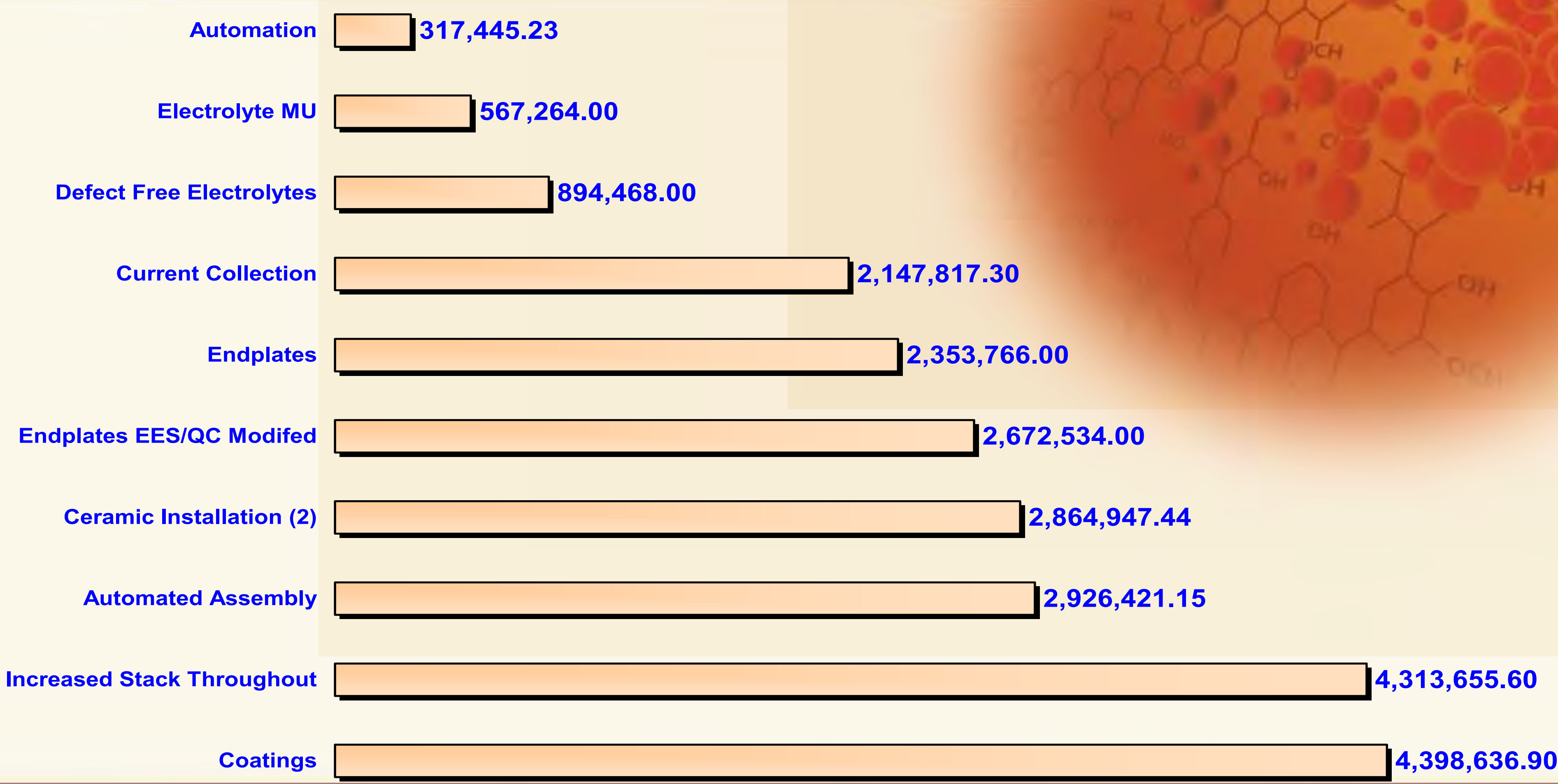
Manufacturing Technology Gap Categories

Manufacturing areas where projects have been Identified To resolve gaps

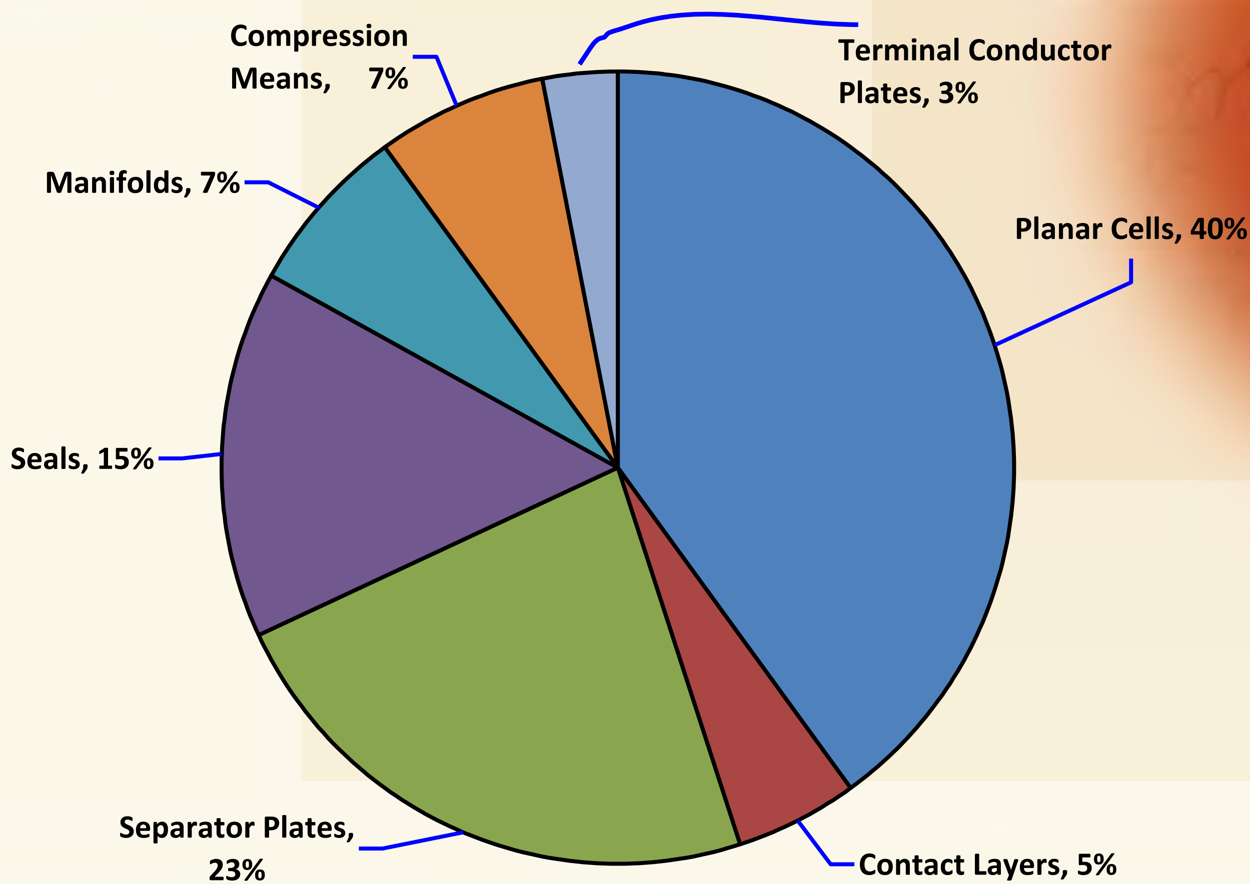
- Production Automation
- Production Materi
- QC during Manufacturing
- QC for Product
- BOP Hardware
- BOP Performance
- Materials
- Design Performar
- Design Controls



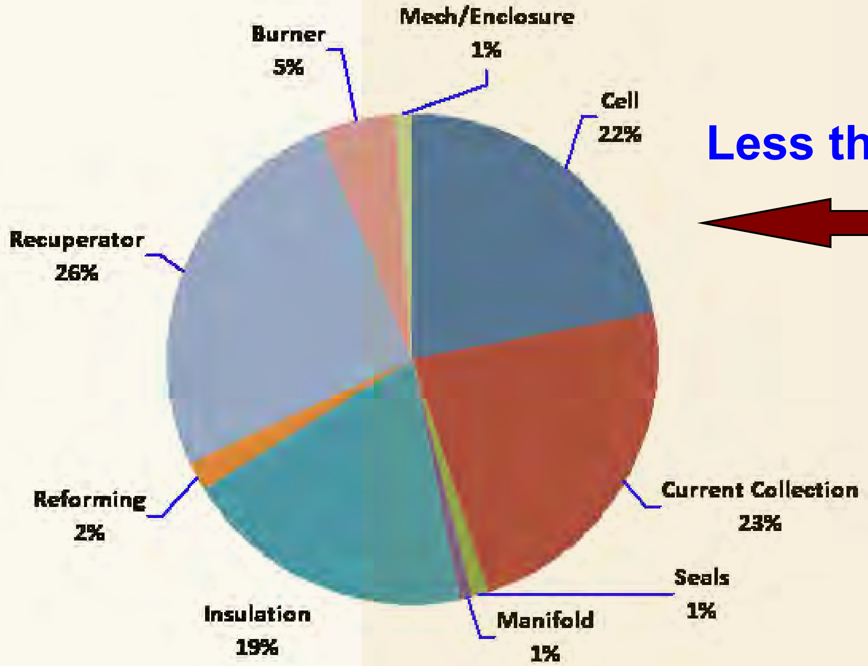
Ceramic Projects



Ceramic Planar Costs

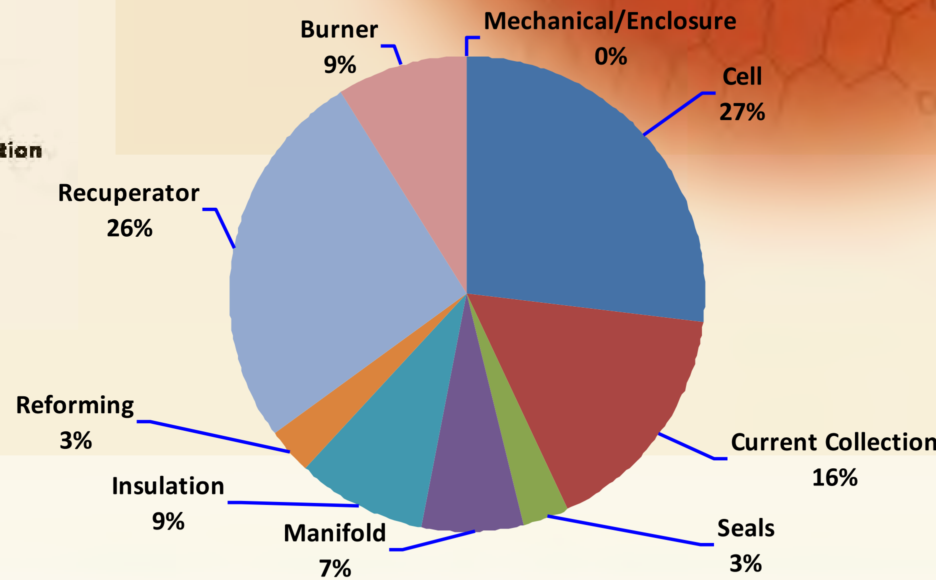


Ceramic Tubular Costs



Less than 500 watt systems

Greater than 500 watt systems



Joint Service Power Expo 2011

Jadoo Power Systems, Inc

Forward Deployable Renewable Energy

Ken Pearson, President and COO

more power. more possibilities.™

Jadoo Military Projects

jadoo POWER

Fuel Cell and Energy Storage Examples

PEPSAE

CCAT & Medical Evacuation

Unmanned Aerial Vehicles

Mako Tiger Shark

Delta II

Field Radio

PPS / G50
Wearable Power

Dry Chemical
Hydride
Hydrogen
Storage

UGS Power

ODIS
Unmanned
Ground
Vehicle

PEPSAE Product Platform

PEPSAE (Aero-Med Transport)

DC Voltage: 12 V / 120V nominal
DC Power: 150 W continuous/ 330 W peak
Energy: 1080 W-hrs. (N-Stor 360)
Weight: 35 lbs. (with fuel)
Dimensions: 16” x 4.8” x 10.5”
Exhaust: warm air vapor
Start-up time: <2 seconds
Safe to Fly

PEPSAE powering all medical devices:

DC Power: 150 W continuous/ 330 W peak
AC Voltage: 120 V nominal (2Connections)
AC Power: 150 W continuous/ 330 W peak
Weight: 5 lbs.
Dimensions: 3” x 4” x 12”

Sweet of Medical Equipment power by PEPSAE

DEVICE	Power Source	Average Current (A)	Peak Current (A)*	Voltage (V)	Average Power (W)	Peak Power (W)	Energy (Whr) for 1 hour
Propaq Monitor 260EL	DC						
NIBP q10 min, Pulse oximetry		1.08	2.2	14.008	15.07	20.9	15.09
Impact 326M Suction Pump	DC						
Continuous, Max vacuum		3.02	6.3	13.92	42.04	42.04	42.04
Zoll-M Series CCT	AC						
Shock 200J 6 Times/hr + 12 lead EKG + Printer		2.60	13.60	13.91	35.62	182.95	35.62
12 lead EKG, Printer		2.56	2.56	13.91	35.60	35.60	35.60
UNI-VENT "Eagle" 754M	DC						
Worst Case		2.96	5.43	13.97	41.64	75.86	41.71
Nominal		1.57	3.00	13.97	22.09	41.92	22.16
IVAC Medsystem III	AC						
999 mL/hr all ports		0.73	0.73	14.00	10.20	10.20	10.20
125 mL/hr all ports		0.66	0.66	14.00	9.28	9.28	9.28

Fuel Cell Products
100w to 330W in two additional platforms

jadoo POWER

XRT 150/300 (Extended Run)

DC Voltage: 12 -13.5 V / 120V nominal
DC Power: 150 W or 300W continuous/ 330 W peak
Energy: : 2160 W-hrs. (6 x N-Stor 360)
Weight: 48 lbs. (with 6 hydrides fuel)
Dimensions: 7” x 14” x 12”
Exhaust: warm air vapor
Start-up time: <2 seconds
Power Distribution Manager 5VDC, 12VDC and 120VAC (True Sinewave)

Power Case 150/300

DC Voltage: 12 V / 120V nominal
DC Power: 150 W or 300W continuous/ 330 W peak
Energy: 1080 W-hrs. (N-Stor 360)
Weight: 35 lbs. (with fuel)
Dimensions: 18” x 7.8” x 14.5”
Exhaust: warm air vapor
Start-up time: <2 seconds
Power Distribution Manager 5VDC, 12VDC and 120VAC (True Sinewave)

Inside the Power Case 150/300

Current users and applications for PowerCase and XRT 150/300

Communications Repeaters

1. **Police**
2. **Sherriff**
3. **Forestry**

Media and Events

1. **NASCAR**
2. **Winter X-Games**
3. **Multiple media events**

Power Distribution

Power Distribution Module(PDM)

DC Voltage: 12 V nominal (6 Connections)
DC Power: 150 W continuous/ 330 W peak
AC Truesine Voltage: 120 V nominal (2 Connections)
AC Power: 150 W continuous/ 330 W peak
Weight: 6 lbs.
Dimensions: 4.4" x 5.5" x 7.5"

Lightweight Military Battery Charging Module

Glen Air Mighty Mouse Connector
DC Voltage: 12 VDC / 5VDC
DC Power: 150 W continuous/ 330 W peak
Weight: .5 lbs.
Dimensions: 2.5" x 1.25" x 5.5"

Battery Charging Demonstration

PEPSAE powering four single soldier chargers with four LI145s. The Status of Charger Indicator (SOCI) on three LI 145s had one green dot (0-20%) and one had two green dots (21-40%). The PEPSAE powered up in four seconds. The chargers operated without any issues with all four receiving power needed to go from “Idle” mode to “Charge” state. The PEPSAE operated at 14 Volts continuous at about 4 Amps and in just over 2 hours charged three of the LI-145, that started with a SOCI of one dot, to three dots, the forth battery charged to four dots.

Energy Storage Platform

jadoo POWER

Metal Hydrides
Jadoo Power's Baseline Technology
Practical Power Limit: 300W
Max Energy Density 1.6 Wt.%
Cost: Medium @ Commercial
Transportation : Limited today
H2 –Physical Storage
Safety ; Excellent

FillPoint (Hydride Refill)
1.5 hours refill

Stationary Refill: Use Pressure Bottle

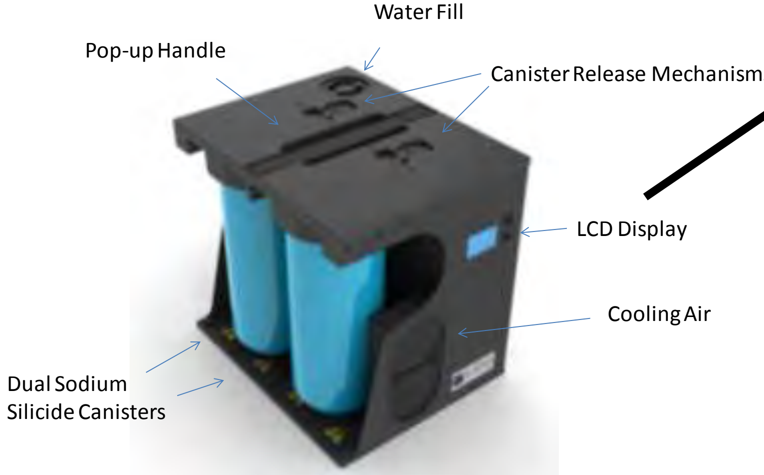
Autonomous Refill with Hydrolysis Chemistry

Integrated electrolyzer planned for 2012

AB Derivatives
Advance Thermal Chemical Generation
Practical Power Limit: 150 W
Energy Density 500 W-Hrs/kg
Cost: High
Transportation: Easier today, unknown later
H2: - Thermal Generation
Safety: Very Stable

Hydrolysis Chemistry

Solid Dry Material
Practical Power Limit 500W
Max Energy Density 3.5 Wt. %
Cost: Low @ Commercial
Transportation: Limited Today
H2: Solid - Hydrolysis
Safety: Very Good

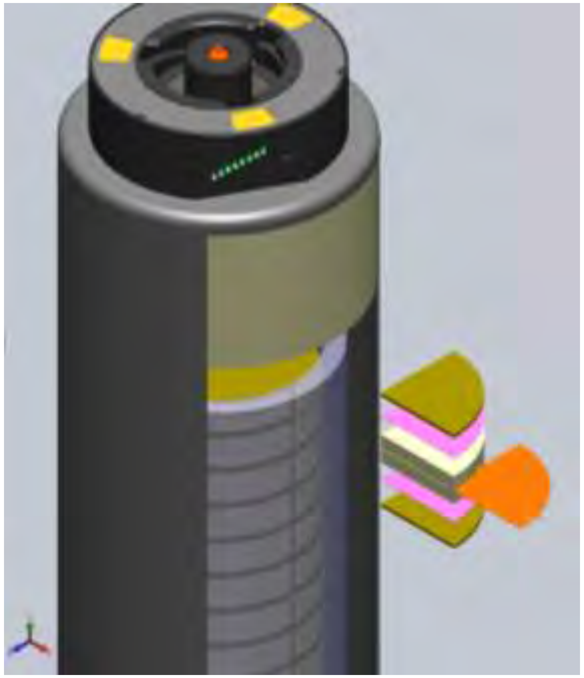


Hydrogen Storage – EDAB development & testing

jadoo POWER

Objective is a 500 W-hr/kg canister design

- Optimized EDAB to thermally decomposition material providing 11% by weight H_2 gas evolution
- Currently optimizing cartridge design using the past three years of development to produce a high density pellet packaging system
- Utilize Computational Fluids Dynamics (CFD) thermal modeling to identify and evaluate additional design optimization
- Testing at cartridge level



Unattended Ground Sensor Power System

Jadoo UGS-20PS

Advance Thermal Chemical Hydrogen Storage
Practical Power Limit: 20 W
Energy Density 500 W-hrs/kg
Cost: High
Transportation: Easier today, unknown later
H2: - Thermal Generation
Safety: Very Stable
Working on systems for 30 day unattended power

Mobile Solid Oxide Fuel Cell Generator

Jadoo and Delphi Automotive Joint Program:

- Funded under DOE Grant
- 3KW SOFC generator
- Utilized standard LPG (propane)
- To be deployed in field trials with NASCAR
- High efficiency and low emissions

Jadoo Solar Products

Solar Thermal

Residential Hot Water

Commercial Hot Water

Solar Electric

Water Wells

Security

Remote Site Power

Lightweight and Rugged ST Collector

Key Product Attributes for Forward Deployment

- 60% lighter than competitive collectors
- Impact resistant
- Shock and vibration resistant
- More efficient than PV

Jadoo's Skyline Collectors

Applications

- Showers
- Sinks/Dishwashing
- Laundry

Military Solar Development

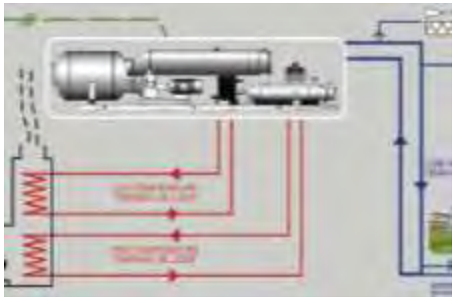
Goals for Jadoo Solar Military Programs:

- Transition commercial Solar Thermal and Solar Electric Systems to Military Applications
- Focus on FOBs
- Add ruggedization and rapid deployment features
- Develop specialized systems to support robust Renewable Energy and FOB Microgrid Infrastructure capabilities

Solar Thermal

Solar Electric

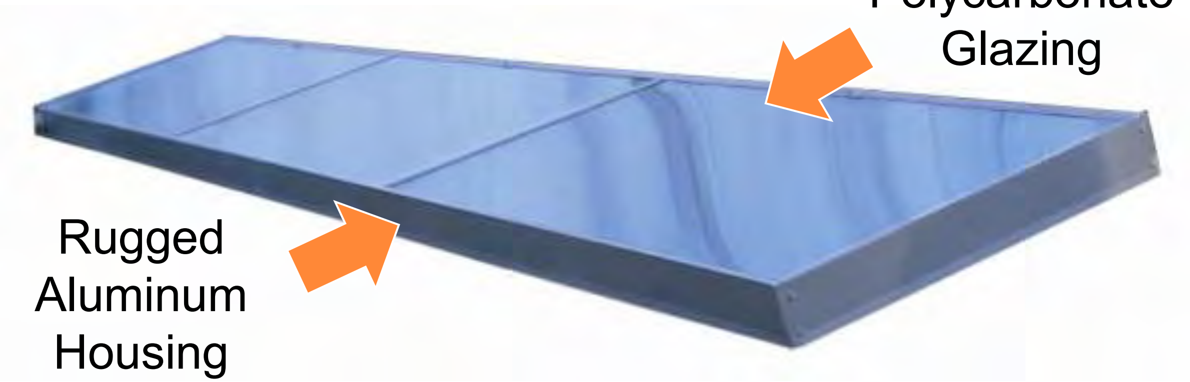
Concentrated Solar



Hybrid Renewable Energy Infrastructure

20 Sqft COTS Product

jadoo POWER



Standard commercial collector, the Skyline 20-01
20 square feet of collector area
144” x 20” x 3”, 38lbs., 1.9 lbs/sq ft.
Produces between 10,000 and 15,000 btu’s per day.
Each panel offsets roughly 4 therms of natural gas per month
Offsets 6 Tons of CO_2 production per year
Or equivalent to not driving a car for 15,625 miles.

Recreational Mobile Solar Trailer

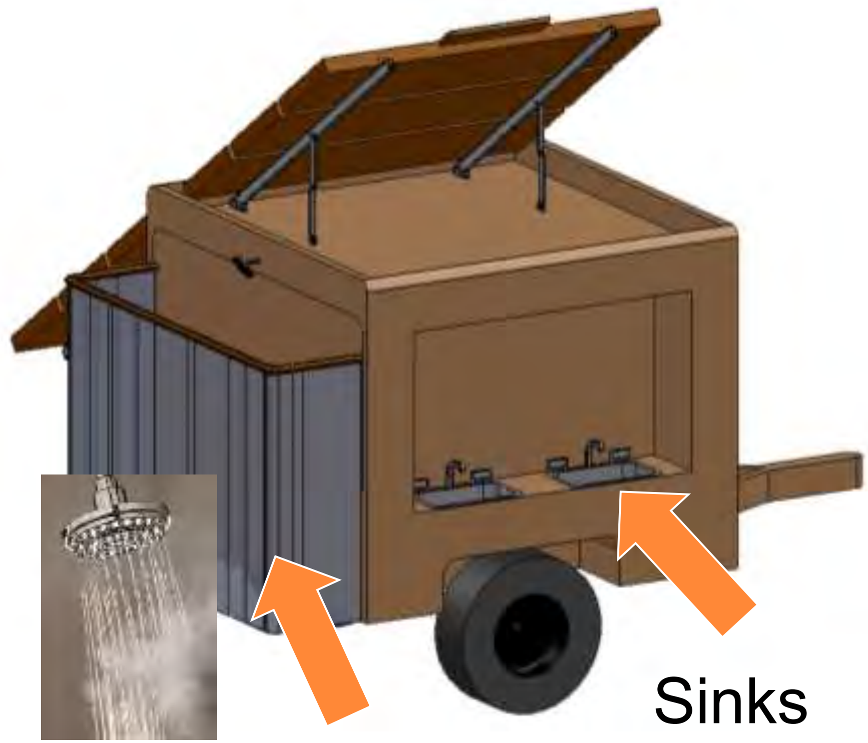
Deployable Mobile Hot Water

Solar Thermal

PV

Solar panels unfold to harvest solar energy

Solar panels stow for transportation

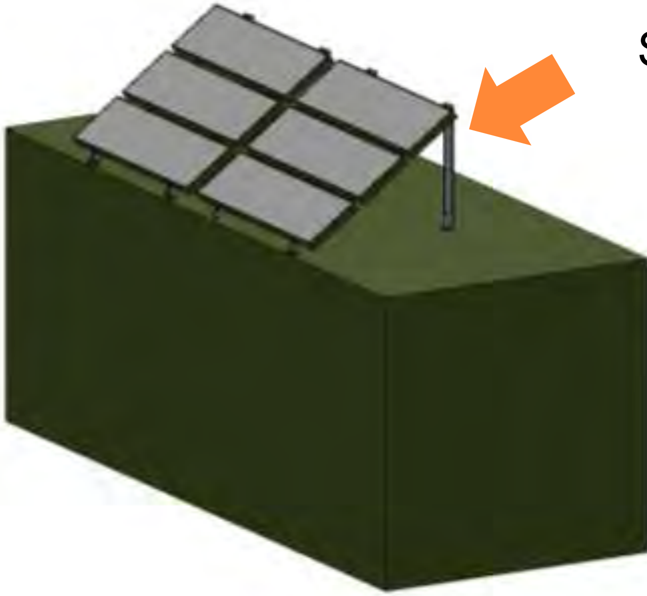


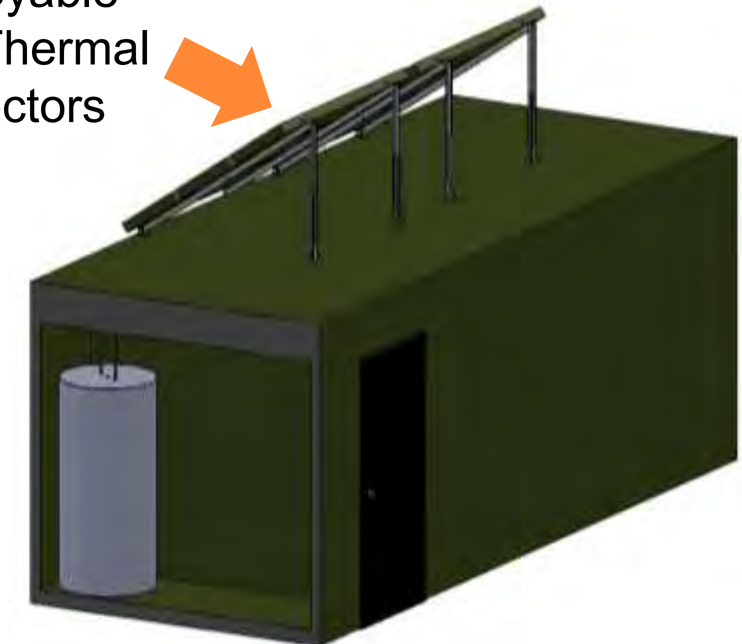
Shower

Sinks

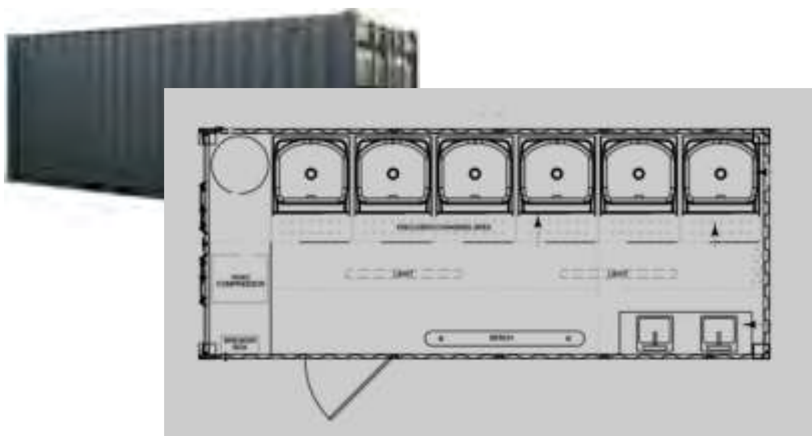
Solar Assisted Shower Unit

Deployable
Solar Thermal
Collectors





Solar Assisted
Hot Water Tank

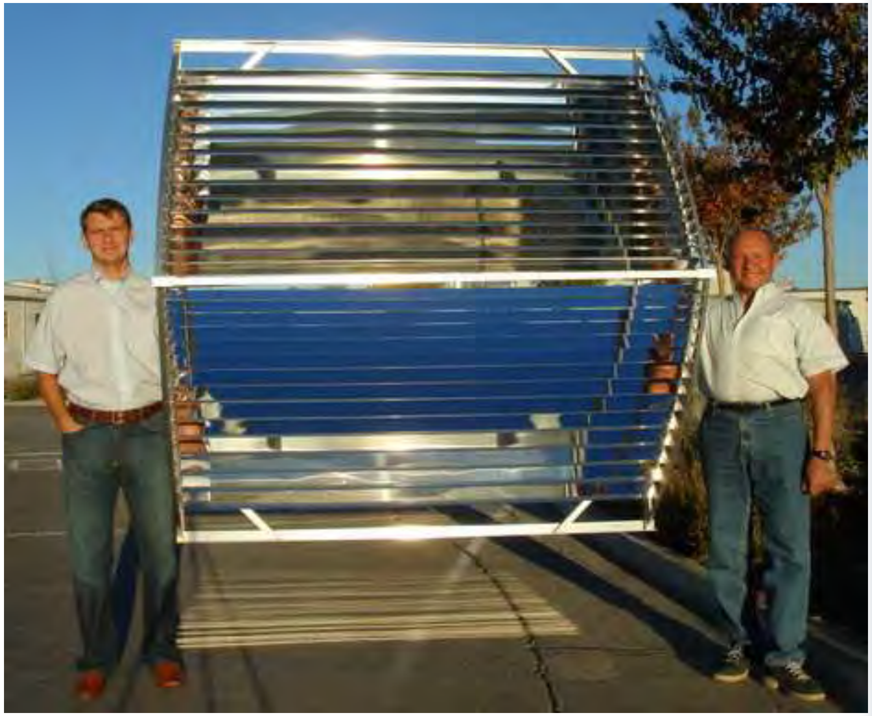


Same Solar System can be used for Kitchen Unit, Laundry Unit, Bathing Unit, Sink Unit

Forward Deployable Solar Concentrator

jadoo POWER

- Lightweight rugged aluminum construction
- Collapsible into flat form factor for transportation
- Easy to setup and tear down in the field
- Good wind loading characteristics
- Requires light duty tracker due to lightweight design
- 200% to 300% better concentration than Fresnel lens

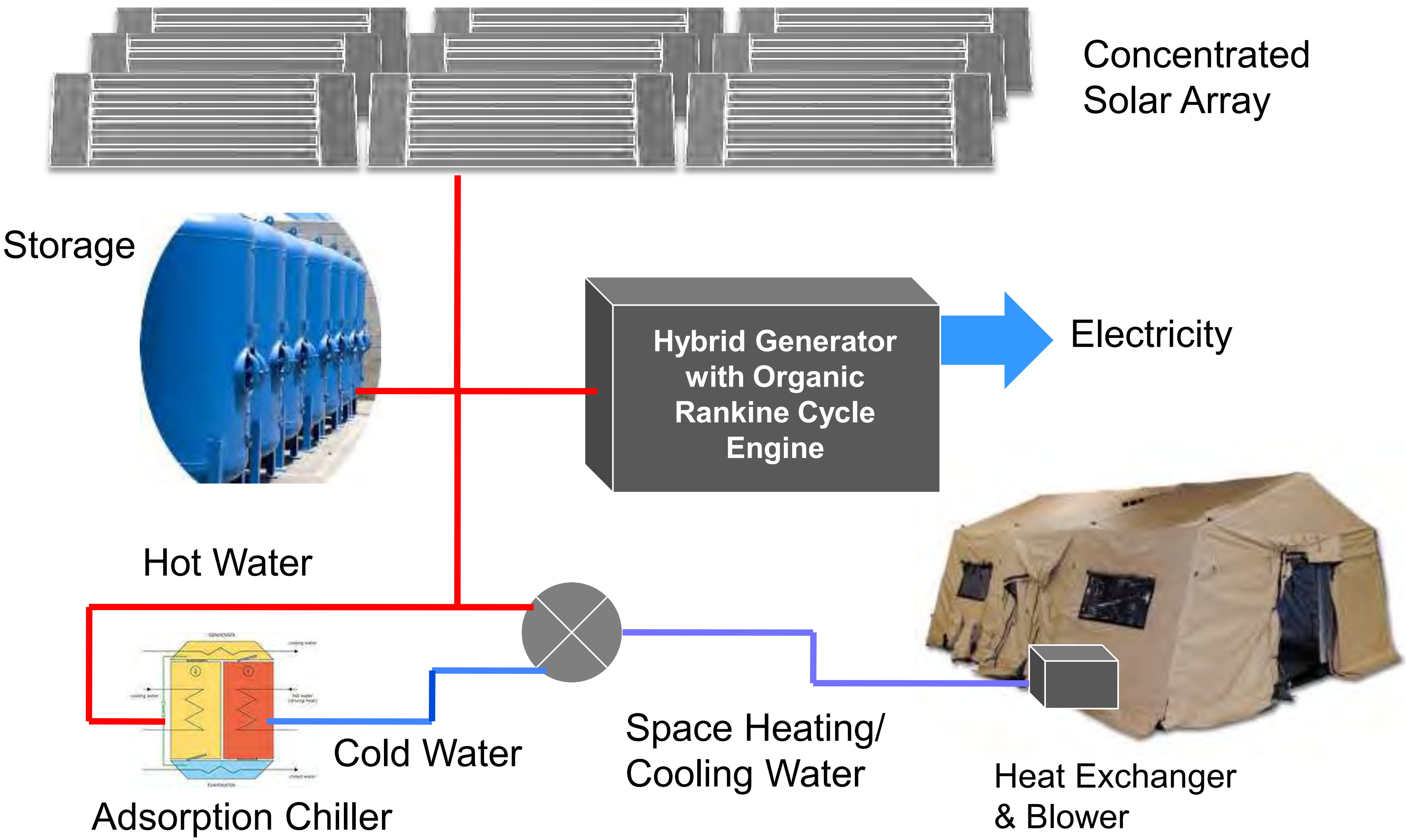


Applications

- Water Heating
- Space Heating & Cooling
- CPV or CSP Electricity
- Combined Heat and Power
- Water purification/desalinization
- Hydrogen generation

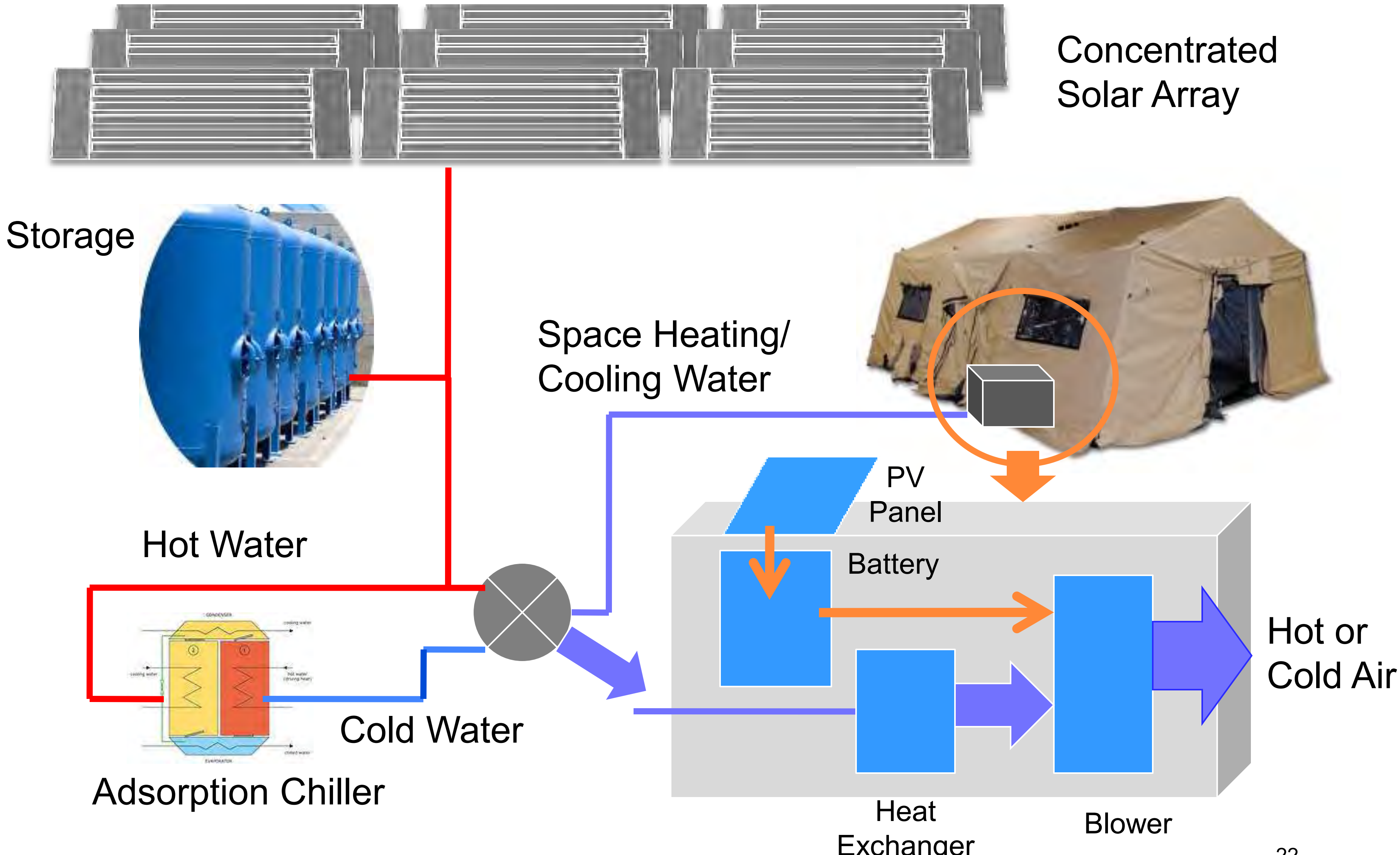
Lightweight, collapsible solar concentrator for redeployable applications

High Efficiency Solar Thermal Cooling/Heating Design (HE-STACH)



Space Heating and Cooling

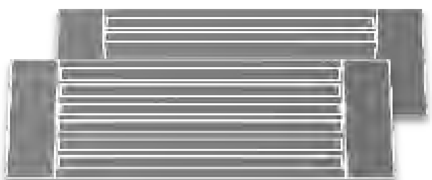
jadoo POWER



Renewable/Fuel Cell Infrastructure

End-to-end Fueling Infrastructure

Concentrated Solar



Solar Thermo Hydrolysis

Hydrogen Filling

Hydrogen Distribution

Portable Fuel Cells

Summary

- There are a number of Renewable Energy Technologies that can be applied to reduce fuel consumption at FOBs
- Commercial technologies will require some degree of ruggedization and modification to support forward deployment
- Key issues will be integrating solutions together that utilize the best form of energy and which allow the tie in of renewable resources with conventional resources in a seamless way
- Jadoo is working to apply its expertise in renewable energy in military products to develop a suite of products to support the goals of decreasing the need for the transportation of conventional fuels to FOBs

Design Development and Testing of the **G**round **R**enewable **E**xpeditionary **EN**ergy **S**ystem

Eric Shields, Alex Askari
NSWC Carderock, 5/4/2011

NAVSEA WARFARE CENTERS Carderock Division

Battery Technology Group

- Three Primary Work Areas
  - Lithium Battery Safety Testing
  - Advanced Battery Development
  - **Renewable Energy Testing and Evaluation**
- Personnel
  - Physicists (2)
  - Mechanical Engineers (4)
  - Chemical Engineers (3)
  - Materials Engineers (2)
  - Technicians (3)

Outline

- Program Goals
- Design Goals
- Technology Selection
- Prototype Development
- Proof of Concept Testing and Validation
- Battery Design/Development
- USMC procurement and fielding
- Conclusions

Ground Renewable Expeditionary ENergy System (GREENS)

- Jointly funded renewable energy development effort (USMC, ONR)
- The scope of the work encompasses two efforts
  - Develop a 300W continuous renewable energy system
  - Test and evaluate COTS systems
- The focus of this presentation will be the developmental efforts associated with the 300W system

GREENS 300W System Design Goals

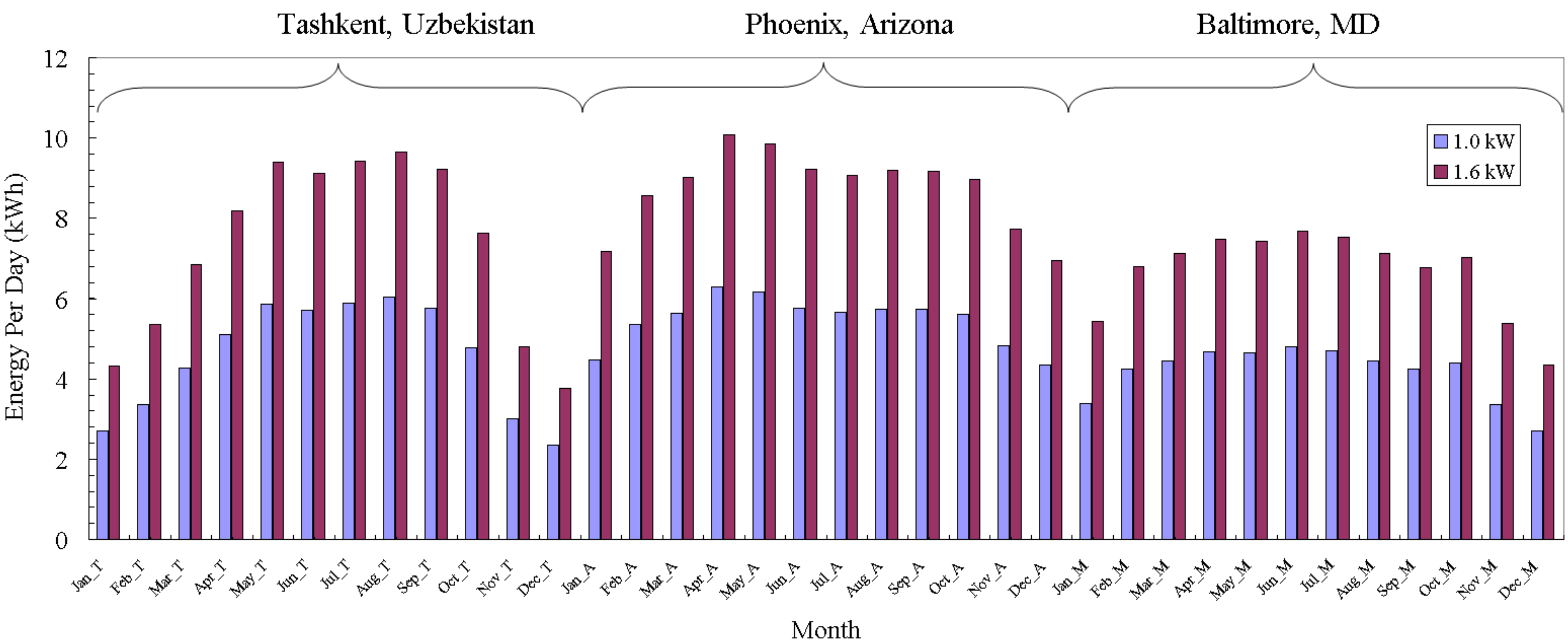
- Provides 300W continuous, 600W peak from a renewable source
  - 7.2kWh per day
  - 4.8kWh of energy storage
- Consists of individual packages weighing less than 80lbs
- Provides 24VDC and 120VAC output (true sine wave)
- Is capable of being setup in under 20 minutes by 4 Marines
- Weighs under 1000 lbs
- Is rugged enough for transport and usage
- Operates between -20°C and 55°C
- Is scalable to optimize the power supply based on a given mission

Solar vs. Wind

- It was determined at the outset that solar would be selected to best meet the requirements laid out by Marine Corps Systems Command
  - Rapid deployment
  - Deployable in nearly every location
  - Minimal required training
  - Reduced signature (No required guyed tower, no noise or EMI concerns)

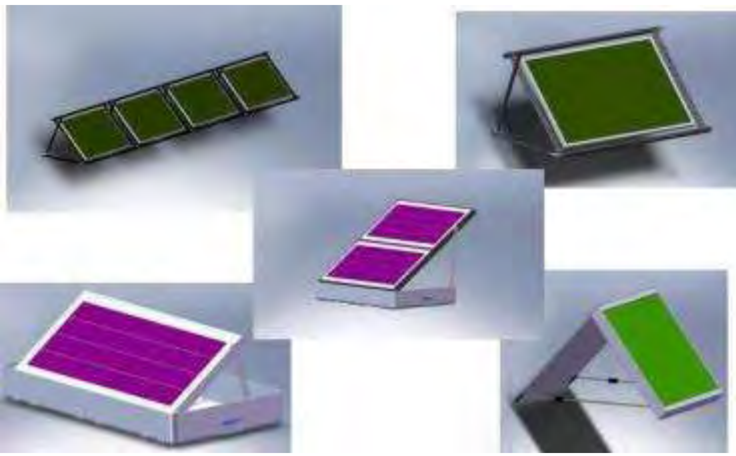
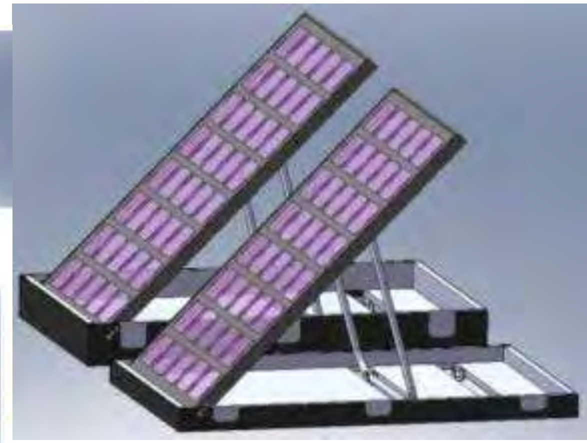
Solar Power Characteristics

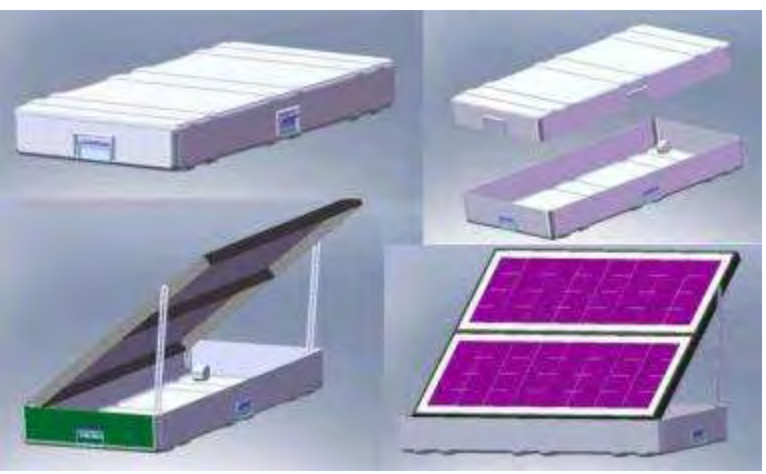
- Location, time of year, and deployment angle all play critical roles in determining solar energy production



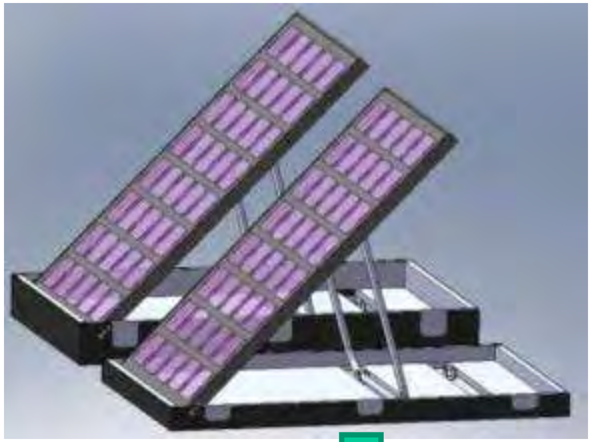
*Data taken from NREL's PVWatts calculator
http://www.nrel.gov/rredc/pvwatts/

GREENS Deployment Concept Development



Deployment Concept Selection



Prototype Evaluation of GREENS: NAWS China Lake

Objectives:

- To demonstrate the prototype GREENS system capable of delivering 300W continuously
- To study the effect of temperature and the harsh environment of the Mojave Desert on the overall performance of the system.

Summary of Energy Generation

Design Goal
300W Continuous

7.2 kWh

Rain all day
Carderock, MD
February 50 F

1.6 kWh

300W for 5 hr

Cloudy all day
Carderock, MD
February 45 F

4.0 kWh

300W for 13 hr

Partially cloudy
Carderock, MD
March 60 F

6.3 kWh

300W for 21 hr

Clear day
China Lake, CA
July 110 F

7.1 kWh

300W for 24 hr

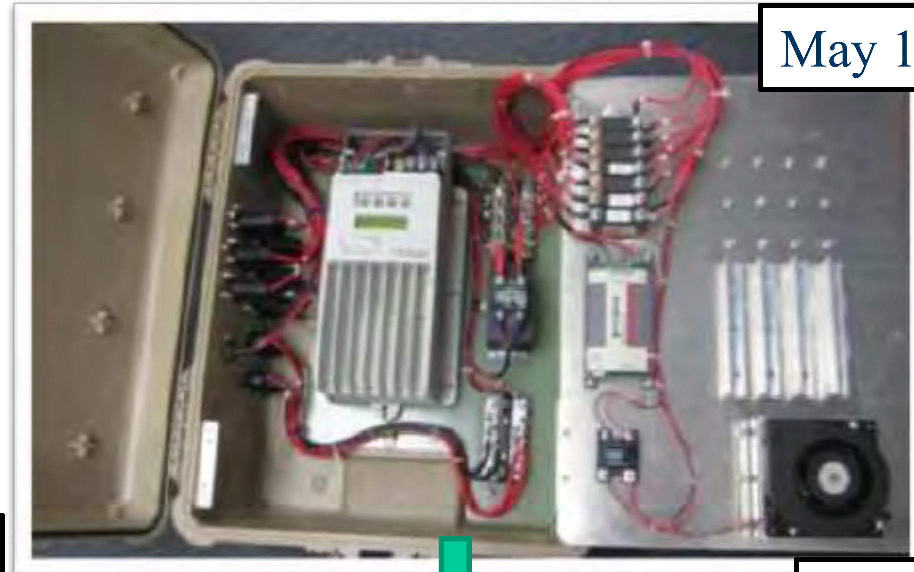
Crystal clear day
Carderock, MD
March 65 F

8.2 kWh

500W for 17 hr

Control Box Development

March 09



May 10

March 10

June 10

Development Timeline

GREENS Tech. demonstrator
NAWS China Lake, CA

GREENS Prototype Camp Pendleton, CA

GREENS Tech. Demonstrator
Ex-FOB Phase II Quantico, VA

GREENS Prototypes Twentynine Palms, CA

India Co. 3/5 Deploys With 7 Systems

From project start to a limited fielding in 23 months!

Need For Production Level System

- EPS worked concurrently during the GREENS development to identify vendors to build the production level system
- Lessons learned and performance metrics from the Prototype systems were used in the performance specification definition
- UEC and HDT were chosen to build prototypes of the production level system
- Testing of those systems is ongoing

Production Version Improvements

	Prototype System	Production System
Continuous Power	300W	300W
Peak Power	600W	**1000W**
Total Weight	1200lbs	**900lbs**
Setup time (4 marines)	10 minutes	10 minutes
Operation Range	0F-140F	0F-140F
Output	120VAC/24VDC	**120VAC/24VDC regulated**
Battery Technology	Lead Acid	**Li-Ion**
Autostart Capability	No	**Yes**
Battery State of Charge Indicators	No	**Yes**
DC Charging	No	**Yes**
AC Charging	No	**Yes**

Why Use Renewables?

Renewables are heavy and expensive but…

- No need to re-fuel the system (Reduced logistics burden). System can be self-sustaining in remote areas
- Short-term weight reduction benefit
- Lifecycle cost benefit
- **Silent operation**
- No mandatory MOS (Operated by the Incidental Operator)
- Reduction in maintenance (no oil/oil filter changes)
- Long lifetime (panels last 25 years)

Conclusions

- Renewable energy systems will never be able to replace conventional power sources for power levels greater than 100kW
- When selected for the appropriate use scenario, rugged renewable systems can be developed and deployed to reduce fuel consumption and benefit the warfighter
- A detailed cost benefit analysis would have to be undertaken to determine under what scenarios GREENS could provide cost savings

Acknowledgements

Sponsors

- Michele Anderson - Office of Naval Research
- Michael Gallagher - PM Expeditionary Power Systems, Marine Corps Systems Command

Team

- Justin Govar, Matt Huffman, Evan Rule, Alex Askari, Calvin Peters, Anthony Suggs, Erick Satchell, Dave Meldrum

Questions?

NAVSEA WARFARE CENTERS Carderock Division

Rugged Battery Case Design

- Lead Acid batteries previously connected manually with no packaging
- Prototype design packaged in a 24V configuration in cases

<u>Tech. Demonstrator Battery</u>

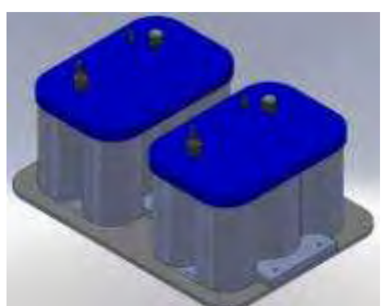
Die Hard Marine Deep Cycle Lead Acid

- 100Ah
- 75lbs

<u>Prototype Battery Design</u>

Optima Deep Cycle Lead Acid

- 55Ah (2 per pack)
- 110 lbs
- 60A Breaker



Merlin Adapters for Tactical Radios
the New Standard in Power Management

Edward J. O'Rourke, CEO
ejorourke@iristechnology.com

May 4, 2011

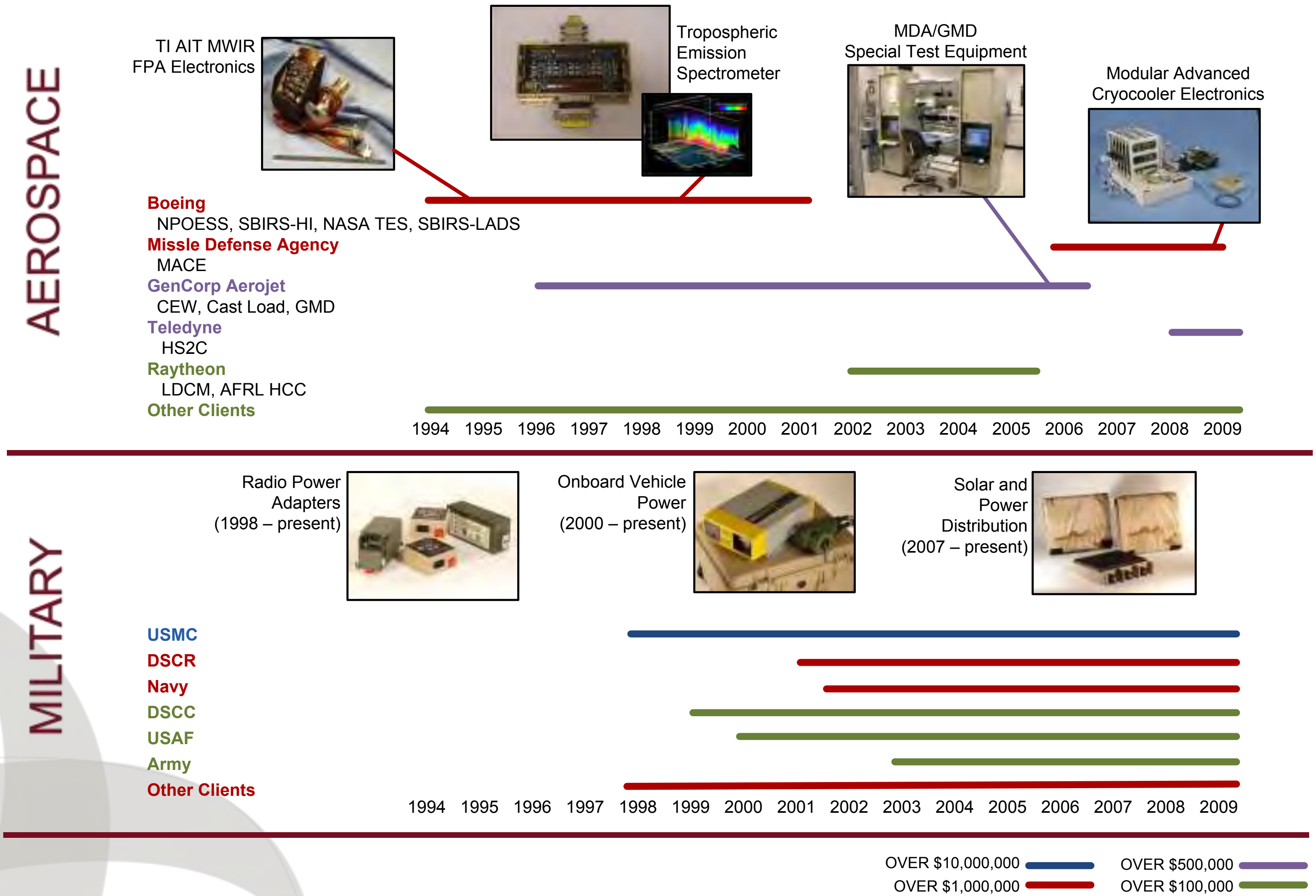
Iris Technology Corporation
PO Box 5838, Irvine, CA 92616-5838
Tel 949.975.8410 Fax 949.975.8498
www.iristechnology.com

Iris Technology at 25 Years

Aerospace Technology
Cryogenics and Imaging
Technology Development

Military Power
Large Production
Intelligent Design

Snapshot of Major Iris Programs Since 1994



Military / SPACES

Tactical Solar Power
2,000 Fielded to Date
Customer: USMC

Military / QuietPower

Vehicle Inverter System
10,000 Fielded to Date
Customer: Joint

Iris Radio Power Adapters (AC/DC)

1996
PAC-216/U
AN/PRC-119D
AC/DC RPA

2006
VB-90
AN/PRC-119F
AC/DC RPA

2003
PAC-24
AN/PRC-117F
AC/DC RPA

IRIS TECHNOLOGY

Iris Merlin-3 Radio Power Adapter

Snapshot:

High efficiency SLICE
Transportable by air
User provided BX-XX90
Reuse radio battery box
Permits battery hot-swap
Variety of I/O accessories

Technology:

Software centric
Smart cable outputs
Native solar capable
High power ~ 240W
High efficiency ~ 97%
Cell energy rebalancing

Other ideas:

Use without battery
Use as battery charger

IRIS TECHNOLOGY

Iris Merlin-2 Radio Power Adapter

Snapshot:

High efficiency SLICE
Transportable by air
User provided BX-XX90(s)
Reuse radio battery box
Permits battery hot-swap
Variety of I/O accessories

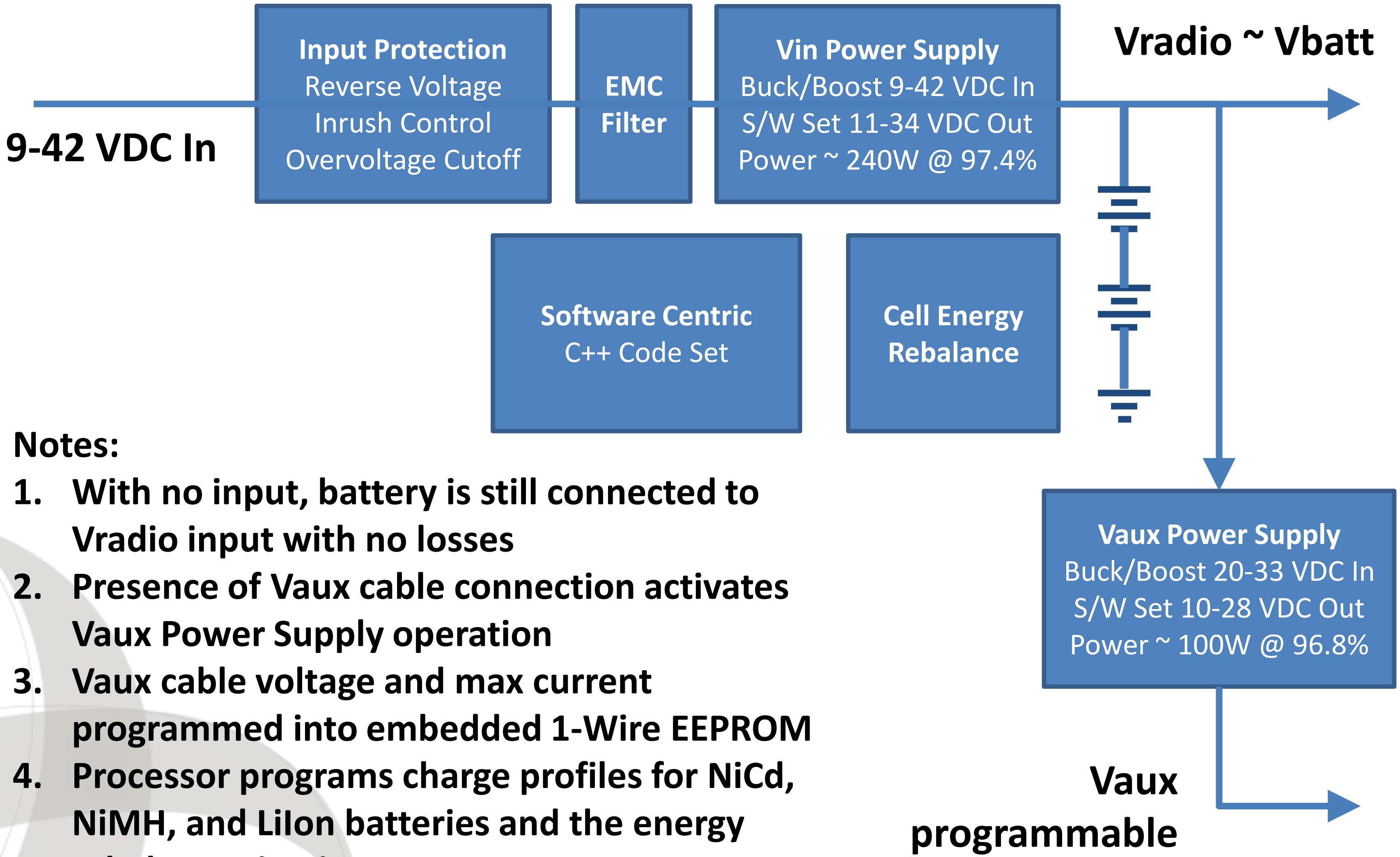
Technology:

Software centric
Smart cable outputs
Native solar capable
High power ~ 240W
High efficiency ~ 97%
Cell energy rebalancing

Other ideas:

Use without battery
Use as battery charger

Merlin Architecture

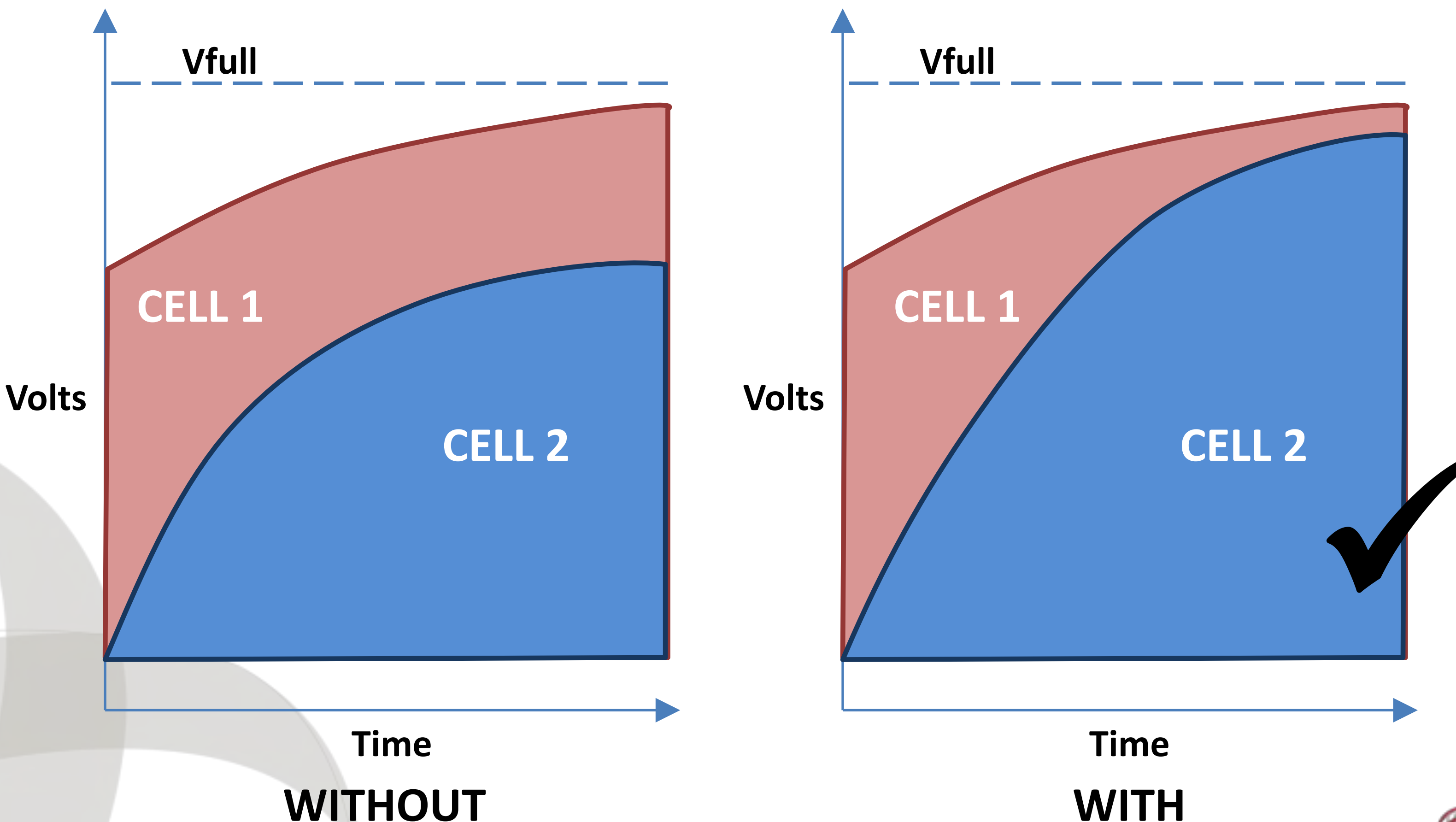


Notes:

1. **With no input, battery is still connected to Vradio input with no losses**
2. **Presence of Vaux cable connection activates Vaux Power Supply operation**
3. **Vaux cable voltage and max current programmed into embedded 1-Wire EEPROM**
4. **Processor programs charge profiles for NiCd, NiMH, and LiIon batteries and the energy rebalance circuit**

Cell Rebalancing

In series charging, cell energy rebalancing shifts charge between cells to provide headroom for full charging of the more depleted cell. Without this rebalancing, charging effectively terminates when the higher energy cell reaches capacity.



IRIS TECHNOLOGY

Iris Merlin-3 Radio Power Adapter

Status:
Available on GS-07F-0131N
Selected by USMC for RPA
M67854-11-A-5044 / $13.5M

GSA Advantage!®
www.gsaadvantage.gov

Parameter	Characteristics
Weight of Merlin-3™	1.8 lbs (829 g)
Size of Merlin-3™	7.6”(L) x 3.5” (W) x 1.9” (H) 193 mm (L) x 89 mm (W) x 48 mm (H)
Input Connector	MS3114-E8-4P
Output Connector	MS3114-E8-4S
Radio Connector	SC-C-179492
Environmental	MIL-STD-810, MIL-STD-461
Housing Material	Aluminum
Operating Temperature	-40°F (-40°C) to +131°F (+55°C)
Storage Temperature	-59°F (-50°C) to +160°F (+71°C)
Input Voltage	9-36 VDC @ 12 ADC (max)
Input Power (max)	280 W @ 24 VDC
Radio Power (max)	26.5 VDC @ 3.5 ADC
Output Voltage	12 or 24 VDC @ 5 Watts for Speakers or 12-28 VDC @ 4 ADC for Auxiliary
Efficiency	97%
BB-2590/U Charge Time	3 hours (typ)

IRIS TECHNOLOGY

Merlin Technology Features / Benefits (1/2)

Features	Benefits
Uses standard, full size rechargeable batteries	• No reduction in runtime when powered from battery • Uses BB-2590/U (preferred) or BB-390B/U (alternate) battery • Programmable charging algorithms ensure future growth capability
Uses existing battery box	• No tools required for installation or use • Using existing parts reduces system cost and weight • Eliminates need to store battery box when using the Merlin-3™
Mechanical latching system allows hot-swap of battery	• Able to change-out battery and recharge extra batteries without power interruption to the radio or crypto-fill loss (when powered externally)
Cell energy rebalancing	• Electronics redistributes charge between cells to create a healthier battery with a higher capacity

IRIS TECHNOLOGY

Merlin Technology Features / Benefits (2/2)

Features	Benefits
Compact size and weight	• Light weight and easy to install • Totally integrated with battery box and radio
Functions with a variety of input and output accessories	• Operates using a wide range of input sources including: native solar, NATO, AC/DC, Zinc-Air batteries, fuel cell, BX-XX90, and personal vehicle • Outputs power to a variety of accessories including speakers, laptop computer and small personal electronics – inverter compatible • Profile consistent with installed base of vehicle mounts
Solar Portable Alternative Communications Energy System (SPACES) Interoperable	• User friendly – no user controls required • Compatible with Iris Technology SPACES elements • SmartCables configure the loads to the auxiliary

IRIS TECHNOLOGY

IRIS
TECHNOLOGY

REMM™ Expeditionary Power

Operational Energy System Solution

Steve Nimmer
Director, Engineering
Defense Technology Development
Oshkosh Defense

REMM™ Expeditionary Power

Mobile & Renewable Operational Energy

<u>Presentation Outline</u>

- DoD “Capability Gap” Challenge
- REMM™ System Inspiration
  - HEMTT A3 Heavy Tactical Vehicle
    - 100 kW Export Power
    - C130 / C17 Aircraft Compatible
    - Enhanced Load Handling System (ELHS)
  - Folding Blade Wind Turbine Innovation
- REMM™ Expeditionary Power Module
  - Design Configuration
    - Specifications / System Performance
    - Product Attributes / Discriminators
- Operational Demonstration Opportunities

CAPABILITY GAP CHALLENGE

- Power and Energy Innovation Workshop – July 2009
  - Army Requirement & Development Commands
    - TRADOC / ARCIC / RDECOM / TARDEC
  - All DoD Services represented
  - National Labs & Academia
  - Industry Experts

- Expeditionary Energy Surety "Help Needed"
  - Support and sustain operations in forward, austere locations
  - Operate with only what you carry in for an extended time period
  - Readily transported within existing military logistics infrastructure
  - Eliminate need for fossil fuel or greatly extend time for fuel resupply

Diesel Electric HEMTT A3
Exports 100 kW of Mil-Spec A/C Power

- Exportable A/C Power
  - 100kW @ 480V or 240V 60Hz
  - 86kW @ 416V or 208V 50Hz
  - 86kW @ 120V 50Hz or 60Hz

Wittman Field: Simulated Disaster
Oshkosh, WI – Sept 2001

Katrina Support: Charity Hospital
New Orleans – Sept 2005

Oshkosh Co. Purchasing Office
Power Outage – June 2008

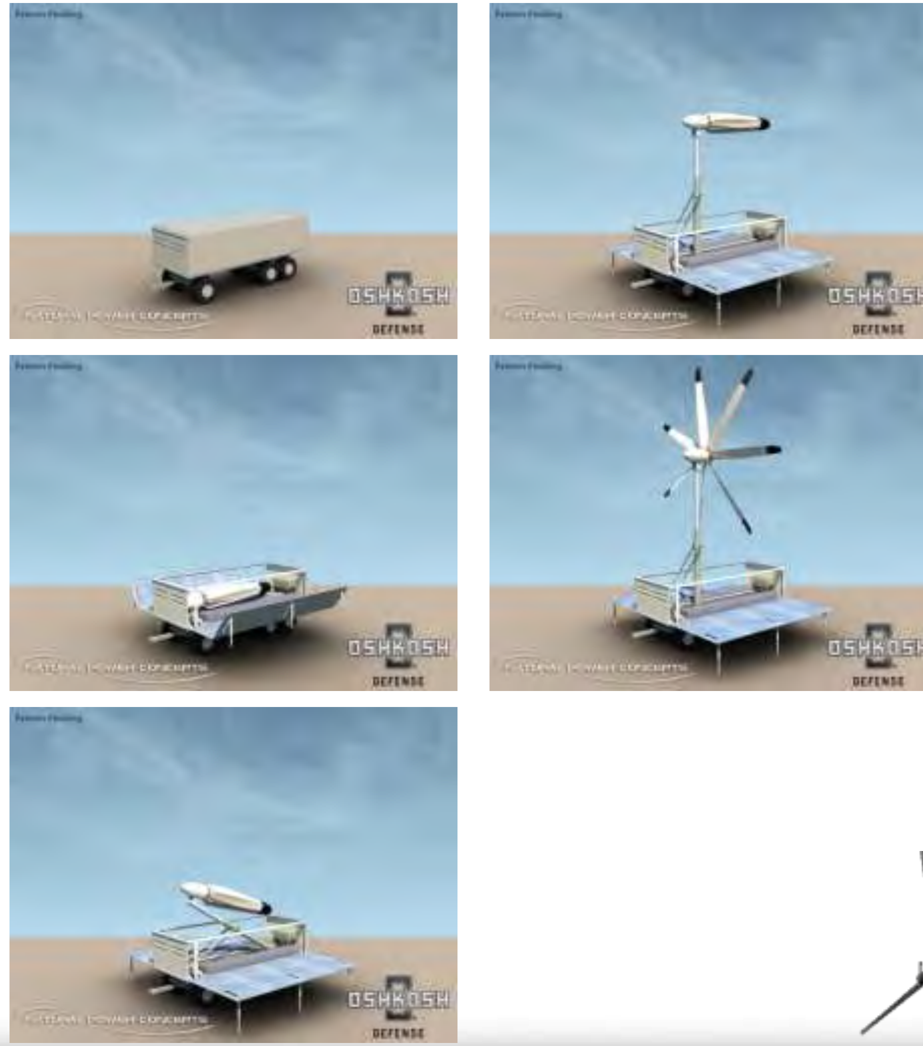
HEMTT A3 + ELHS = Logistics Enabler
Enhanced Load Handling System (ELHS)

- Transports 13-Ton Payload
  - 20’ Standard or CROP style Flatrack
- Loads/Unloads 13-Ton Cargo
  - Ground ↔ Truck
  - Truck ↔ Trailer
  - C130 ↔ Truck
- HEMTT A3 is C130 / C17 Transportable

REMM™ - Folding Turbine & Mobile System Concepts

- Natural Power Concepts
  - Technology Incubator Co.
  - John Pitre: Inventor & Founder
  - Multiple Patents Pending

- Technology Licensed to Oshkosh Defense



Under license from Natural Power Concepts, LLC

Patents Pending

Proof of Concept Folding Blade Turbine

- NPC / John Pitre Invention
  - Quarter scale working turbine
  - Initial testing in Hawaii
  - Energy production
  - Power conversion efficiency

Under license from Natural Power Concepts, LLC

Patents Pending

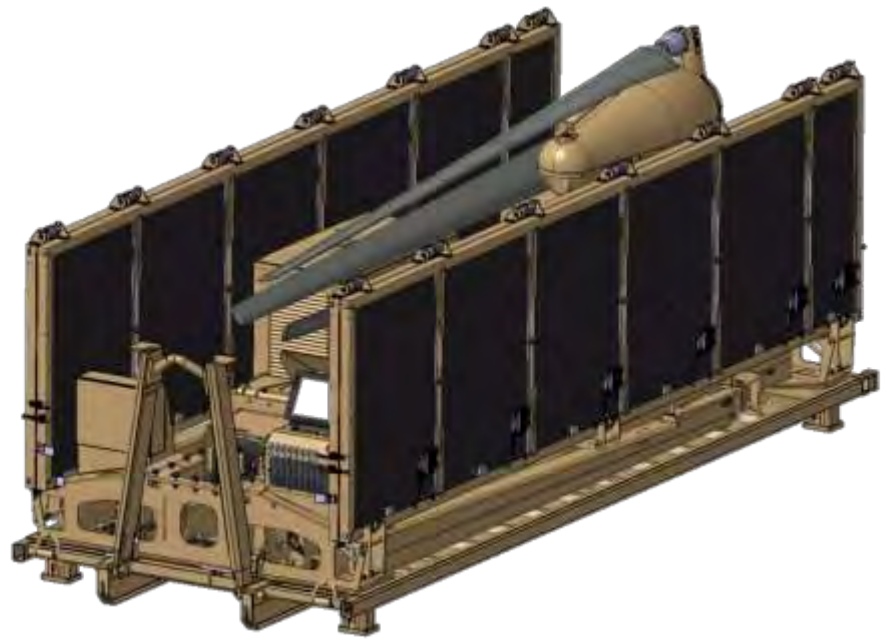
REMM™ Expeditionary Energy - Concept Video
GVSETS / AUSA 2009
HEMTT A3 & PLS Trailer Transporting REMM™ Modules

Oshkosh REMM™ Expeditionary Power Module Configuration – May 2011

Under license from Natural Power Concepts, LLC

Patents Pending

REMM™ Deployed

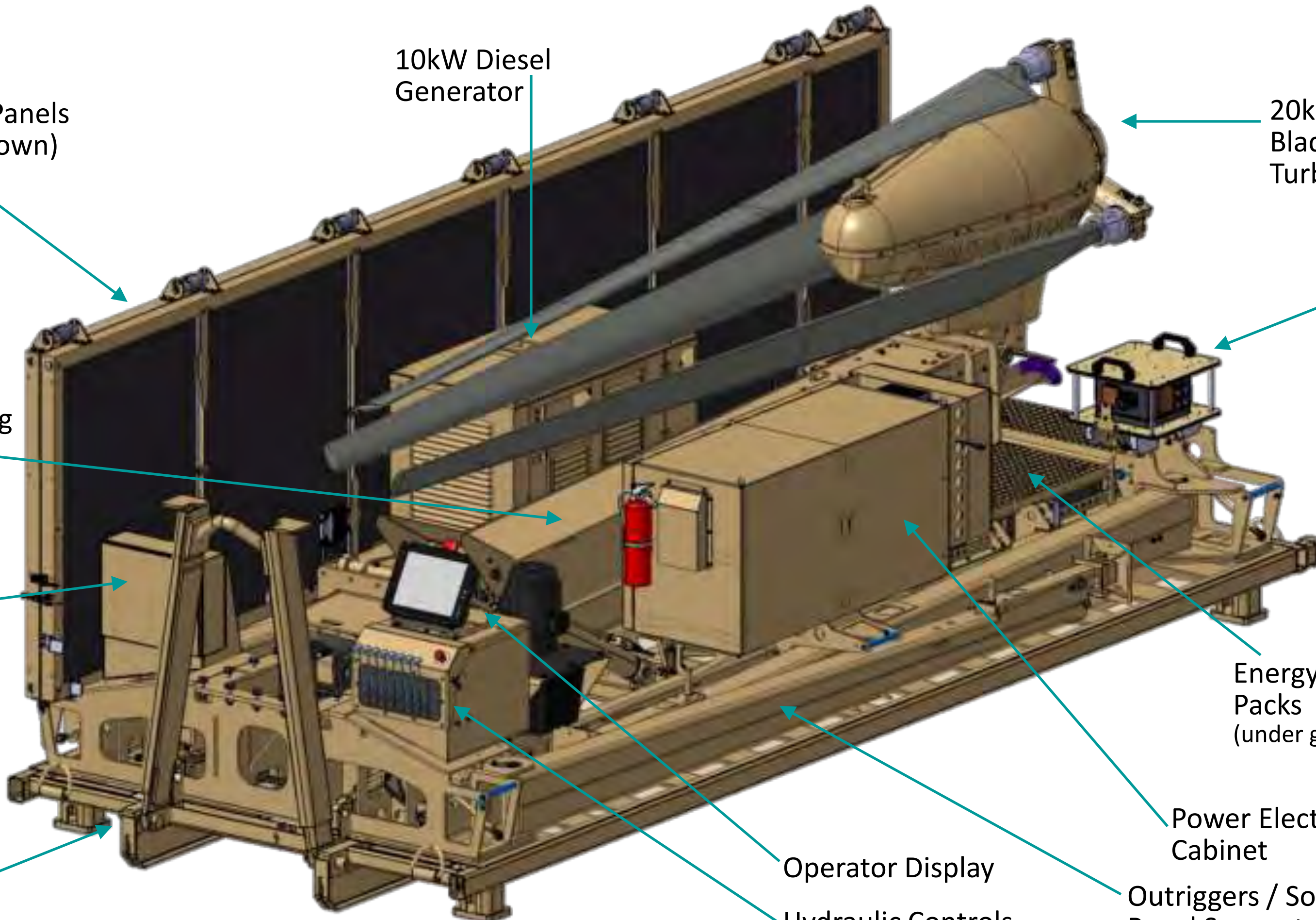


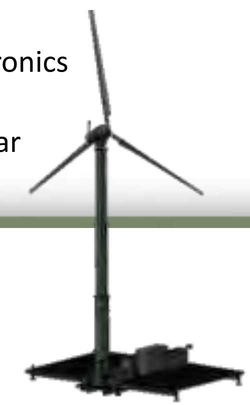
REMM™ Stowed for Transport

REMM™ in Transport Configuration

Under license from Natural Power Concepts, LLC

Patents Pending





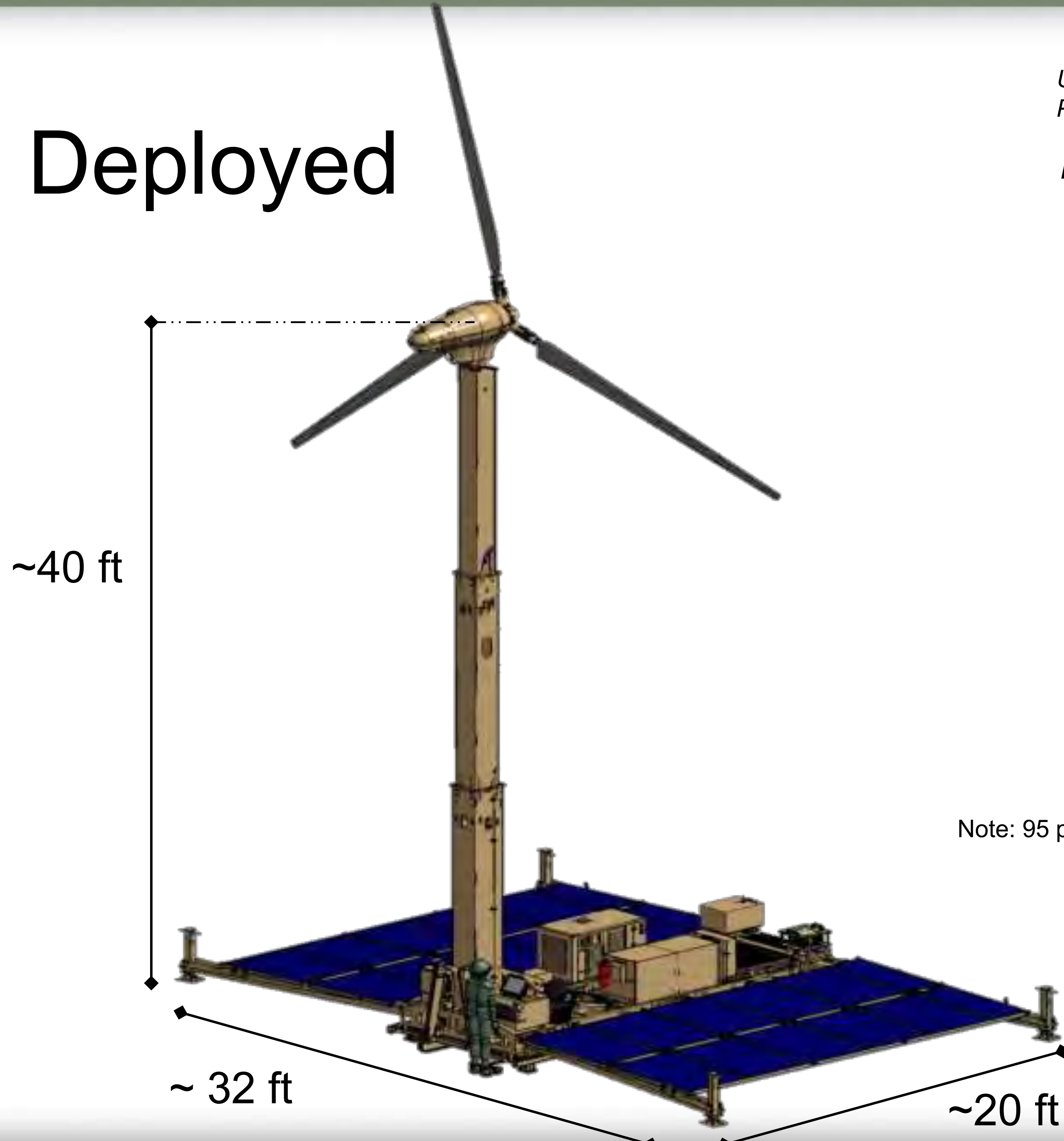
OSHKOSH DEFENSE

REMM™ EXPEDITIONARY POWER

REMM™ Deployed

Under license from Natural Power Concepts, LLC

Patents Pending



Note: 95 percentile soldier shown

REMM™ Deployment Process

Under license from Natural Power Concepts, LLC

Patents Pending

REMM™ Technical Demonstrator Specifications

- ISO container with REMM weighs ≤ 13 Tons

- REMM system output rating
  – Continuous output = 10kW
  – Peak output = 20 kW

- Wind turbine energy production
  ≥ 2.0 kW @ 10 mph wind
  ≥ 5.0 kW @ 14 mph wind
  = 20.0 kW ~ 25 mph wind

- Solar energy production
  ≥ 4.5 kW

REMM™ Technical Demonstrator Specifications (cont'd)

- Energy storage system features:
  - Two light weight Li-Ion battery packs
  - 4 hours of 10kW continuous output
- 10kW on-board backup generator
  - Needed to guarantee a 24 / 7 output system rating
  - DF2 / JP8 fueled with 24 hour fuel capacity
  - Automatically activated on demand
- Export power off-grid electrical distribution box
  - 120 V, Single-Phase A/C @ 60 Hz
  - 208 V, Three-Phase A/C @ 60 Hz

REMM™ System Attributes

- Renewable energy / transportable micro-grid solution
- For remote, austere locations / expeditionary or humanitarian missions
- 34’ or 38’ diameter blade sweep options
- Wind turbine designed to maximize energy conversion in low winds
- Folds for transport on 20 ft LHS transportable platform
- Slides inside a standard 8’ x 8.5’ x 20 ISO container
- Transports on a C-130 cargo aircraft
- Drive on/off C-17 aircraft capability on HEMTT A3 or PLS Trailer
- Operates as a stand-alone “off-grid” system
- Options for “grid-tied” REMM
- Automated, self-contained, self-managed control system
- Wireless remote system monitoring capability

REMM™ Product Discriminators

- Folding blade invention enables largest transportable wind turbine
  - Size matters: Blade swept area impacts wind energy production
  - Larger wind column = Greater wind energy conversion
- Designed around existing military transport logistics
  - 13-Ton LHS equipped Tactical Wheeled Vehicles (TWV)
  - C-130 and C-17 cargo air planes
  - Standard ISO container compatible
- Rolling micro-grid solution
  - Convenient set up, takedown, and redeployment
  - Options for off-grid / grid-tied solutions
  - Standalone micro-grid or micro-grid power source
  - Fully automated control with remote monitoring capability

Operational Demonstrations
Oshkosh Defense Planning in Process

For more information:
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Defense Technology Development
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snimmer@defense.oshkoshcorp.com

Under license from Natural Power Concepts, LLC

Patents Pending

REMM™ EXPEDITIONARY POWER MODULE

RDECOM

Technical Challenges for Vehicle 14V/28V Lithium Ion Battery Replacement

TARDEC

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

David Skalny

Deputy Team Leader, Energy Storage Team, US Army TARDEC

May 4, 2011

Agenda

- Goals & Mission
- Introduction
- Power & Energy Requirements
- Army Applications & Approach
- Characteristics of Lithium-Ion & Lead Acid Batteries
- Lithium-Ion Battery Replacements for 14V & 28V
- Battery Voltage Requirements
- Battery Size Considerations
- Lithium Battery Performance at Extreme Conditions
- Battery Management System
- Battery Charging
- Battery Cost & Weight
- Conclusions

Energy Storage Goals and Mission

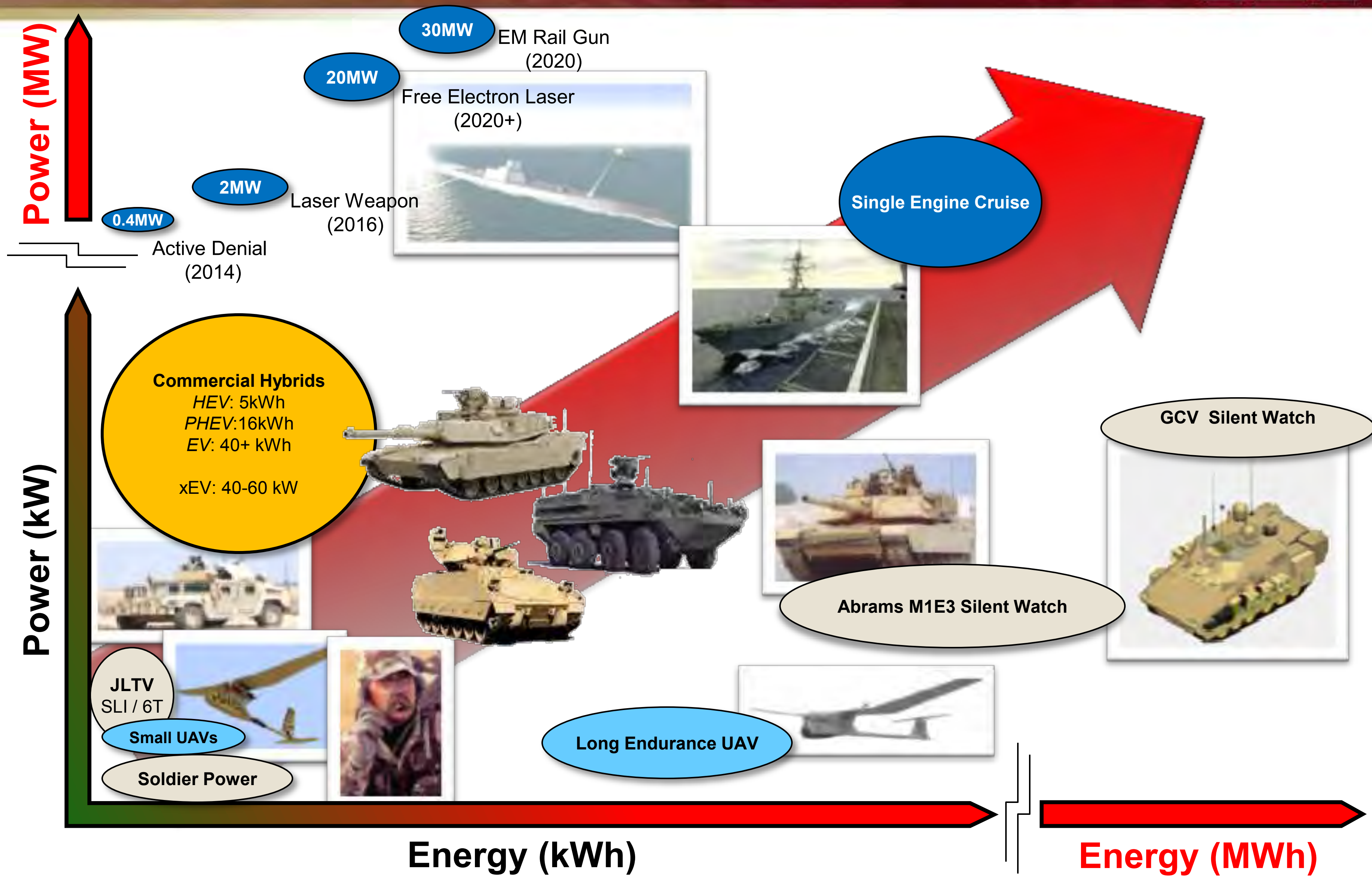
Energy Storage Goals

- Develop **safe and cost** effective energy storage systems
- Reduce **battery weight & volume burden** (Increase Energy & Power Density)
- Reduce logistics and fuel burdens
- Extend **calendar and cycle life**
- Enhance performance and increase operating time (silent watch, etc)

Energy Storage Mission

- **Develop** and **mature** advanced ES technologies for transfer to vehicle platforms
- Test & evaluate ES technologies for prequalification and to assess their TRL
- Identify **technology barriers** and develop technical solutions
- Provide technical support to customers, other teams and government agencies for all ES requirements
- Provide **cradle-to-grave** support for all Army ES systems

Power & Energy Requirements



Army Applications & Approach

- **Army Applications/Drivers:**

  TARDEC - Ground

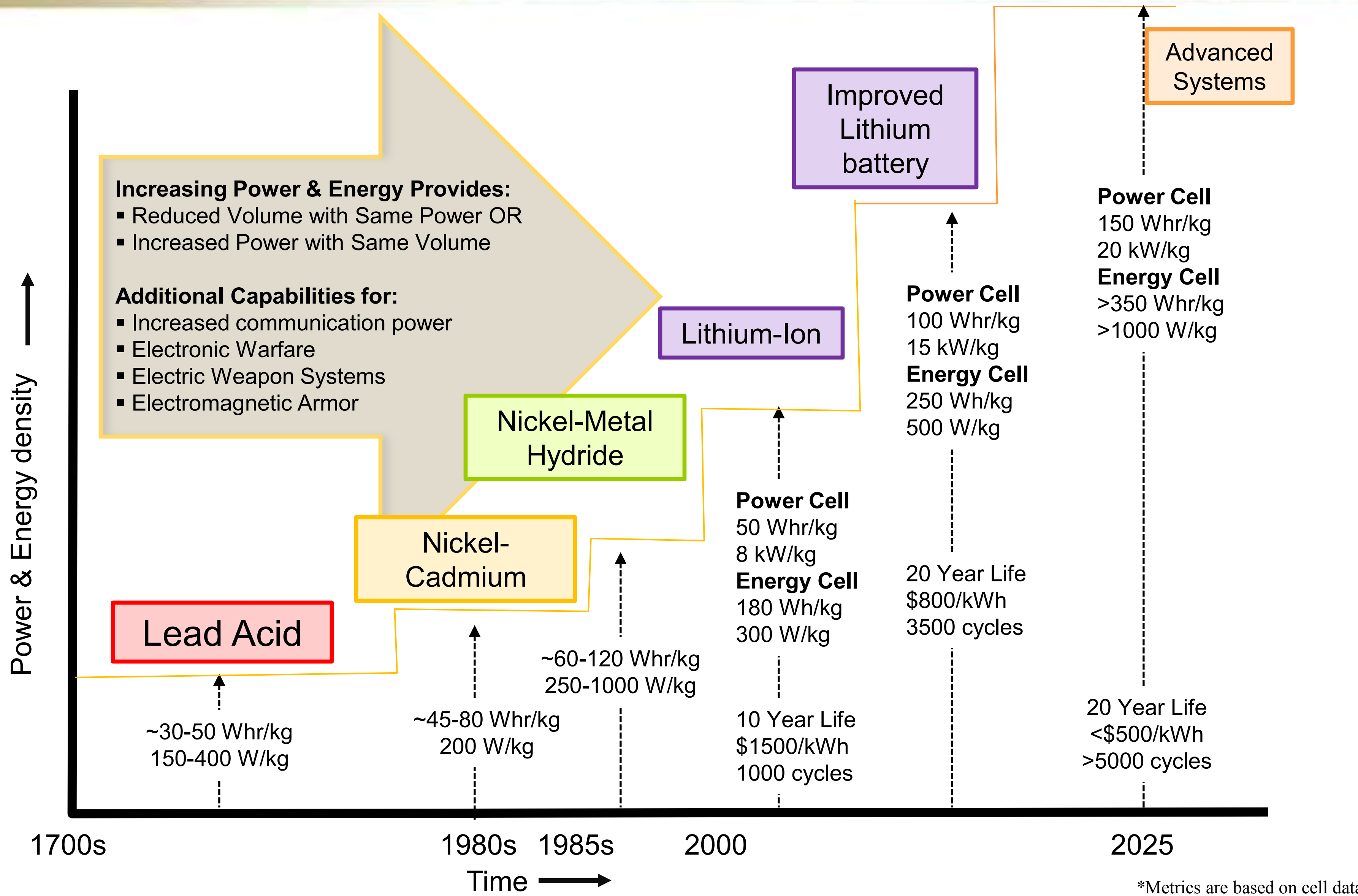
  - Major Applications
    - Robotics
    - Survivability
    - Weapons Systems
    - Electromagnetic Armor (EM Armor)
    - Starting, Lighting and Ignition (SLI)
    - Hybrid Vehicle Acceleration and Silent Mobility
    - Silent Watch
  - Approach
    - Standard Form Factor (6T)
    - Ultra-capacitor/Battery/Fuel Cell Hybrid Power Sources

Hit Avoidance

Targeting Systems

- **Key Energy Storage Challenges:**
  - Battery safety & reliability
  - Higher energy / higher power designs & chemistries
  - Manufacturing process development and cost control
  - Thermal runaway process and its control
  - Standardization of cells, modules and pack

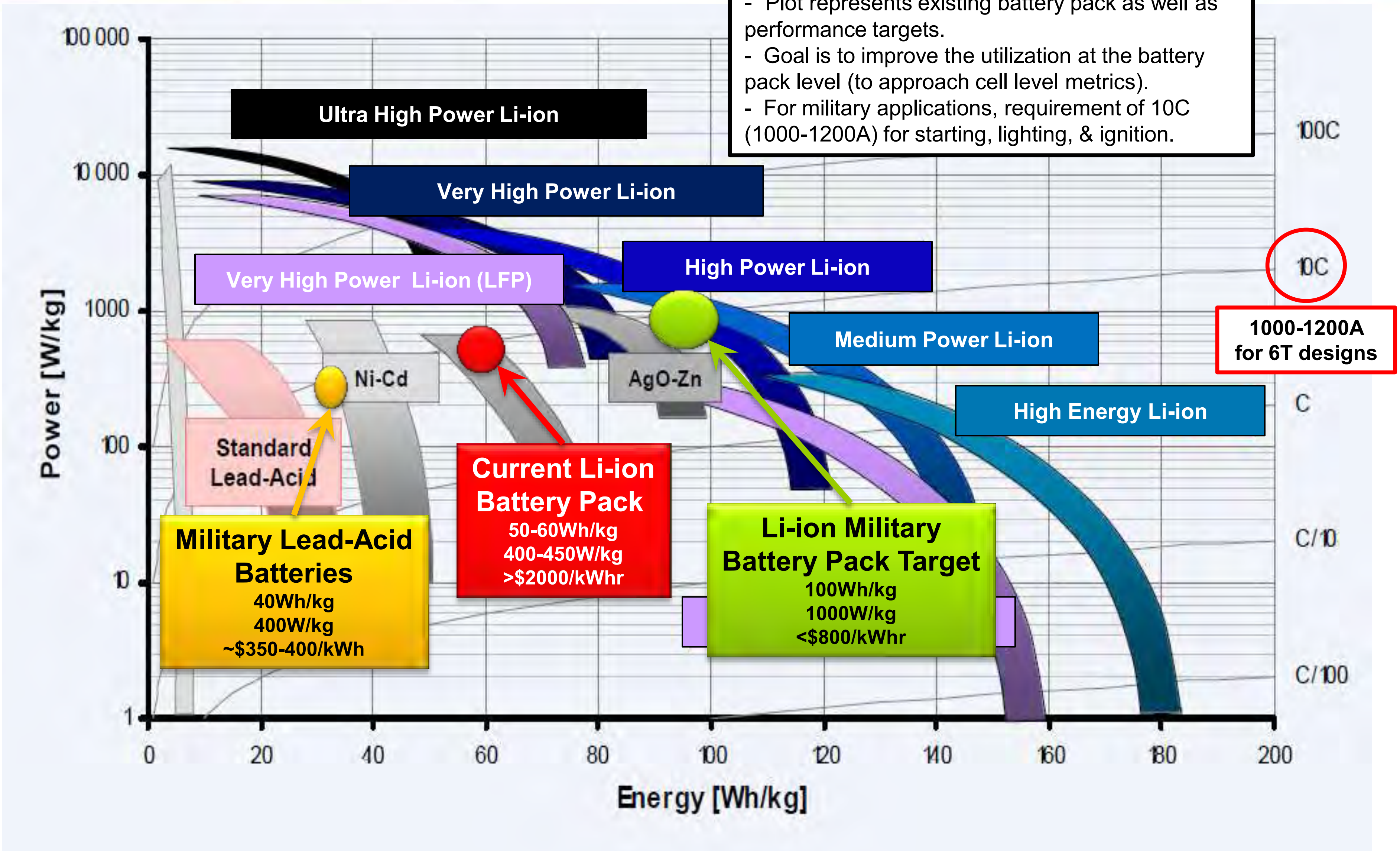
Battery Power & Energy Versus Time (Technology Roadmap)



*Metrics are based on cell data

Energy Storage Technology: Ragone Plot (with Military Pack Targets)

- Plot represents existing battery pack as well as performance targets.
- Goal is to improve the utilization at the battery pack level (to approach cell level metrics).
- For military applications, requirement of 10C (1000-1200A) for starting, lighting, & ignition.



Battery Logistic Burden

AGM Battery Failures 2002-2008	~5%
Incorrect Voltage Output	50%
Damaged - Transport Issues	30%
Improper Electrical Performance	20%

Approximately 80% of incorrect voltage failures were serviceable

Improved charging techniques can lead to 2X life improvement

Fire Suppression

Hit Avoidance System

Communications Systems

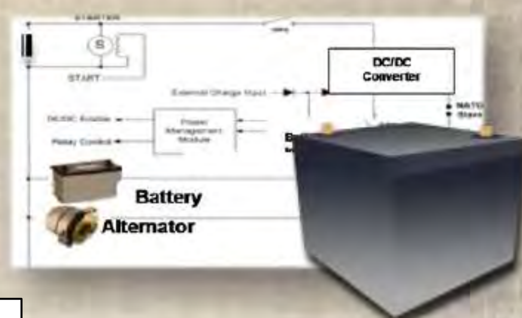
Autonomous Navigation System

Embedded Training

Crew Station/ Displays

Field Battery Maintenance & Training

Improved Charging



Battery Management

* AGM = Absorbed Glass Mat.: "maintenance free"

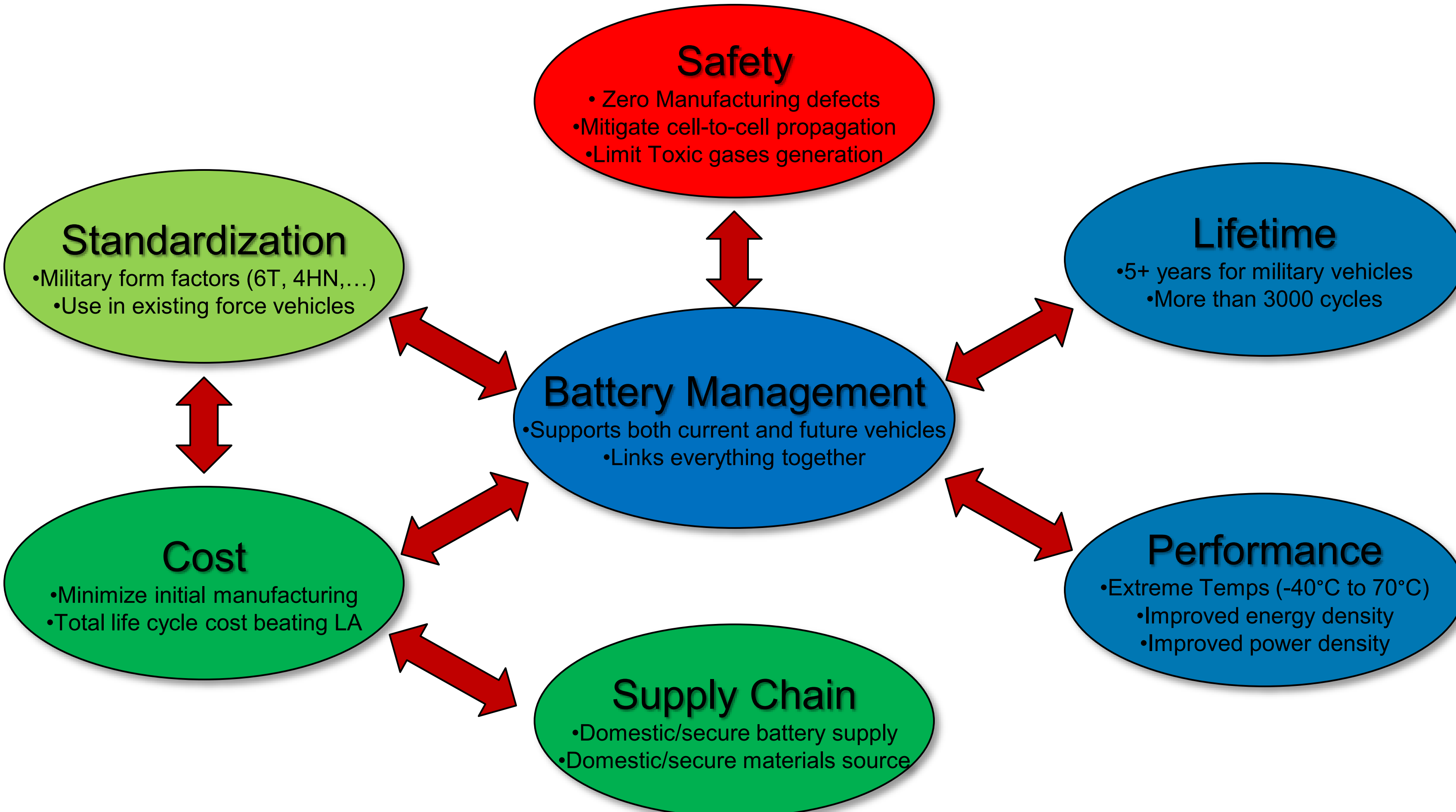
It's All About The Warfighter

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

UNCLASSIFIED

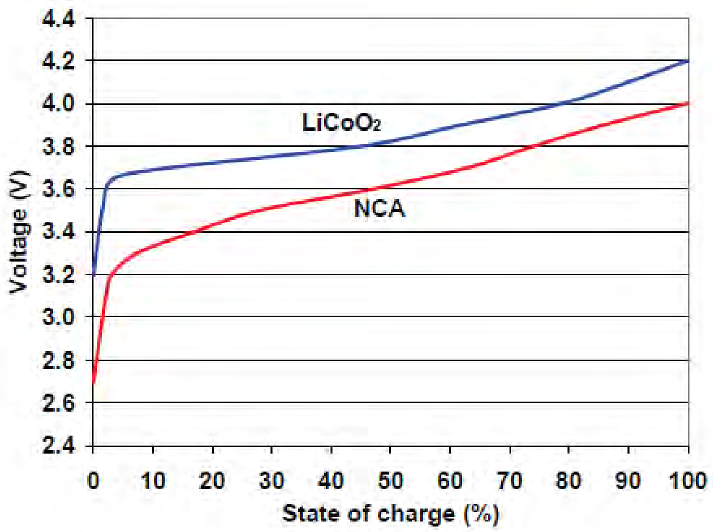
Key Success Factors For Li-ion Battery Replacement

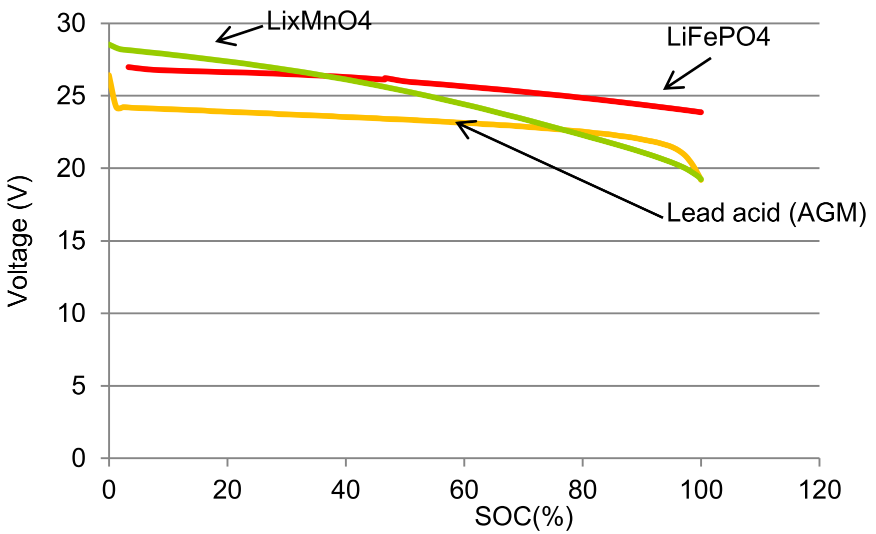
Successful introduction of Li-ion Batteries depends on a number of factors:



Lithium Ion Batteries and Lead Acid Batteries

Battery Chemistry	Specific energy (Wh/kg)	Specific power (W/kg)	Energy Density (Wh/l)	Cycle life	Working tem range
Li-ion	120~200	200~3000	300~600	>1000	-30^{o}C-60^{o}C
Lead Acid	~40	300~650	80~120	100~300	-30^{o}C-70^{o}C





The charge-discharge characteristics of Li-ion and lead acid batteries

Table 2 – Battery voltage

Battery Standardization - Design

- Li-ion battery has to work with existing vehicle electrical system
- Li-ion battery is sensitive to the battery overcharge
- Li-ion battery is sensitive to the battery overdischarge

# of Cells	1	3	4	6	7	8	n
Nominal Voltage(V)	3.7	11.1	14.8	22.2	25.9	29.6	n x 3.7
Voltage range (V) (NCA, NCM)	2.5-4.1	7.5-12.3	10-16.4	15-24.6	17.5-28.7	20-32.8	
Nominal Voltage(V) ($LiFePO_4$)	3.3	9.9	13.2	19.8	23.1	26.4	n x 3.3
Voltage range (V) ($LiFePO_4$)	2.0-3.7	6-11.1	8-14.8	12-22.2	14-25.9	16-29.6	

Battery Standardization - Size

- **ARMY's focus is to develop Li-ion batteries in existing lead acid standardized form factors (such as 6T, 4HN, Group 31 and Group 34)**
  - Development of a set of standardized battery packs would allow for standardization of components – provide significant cost benefits.
- **Implementing a 6T size battery form factor (10.5in. X 10 in. x 8.5 in.) would provide the following for a Military vehicle battery:**
  - Allow of the use in both current force vehicles (as replacement for existing lead acid batteries) as well as next generation vehicles that are designed to utilize Li-ion batteries.
    - ➢ Increased flexibility in field – can use either Lead acid or Li-ion batteries depending on availability.
  - To reduce logistic burden – support limited number of battery sizes in field.
  - Cost benefits (leverage volume).

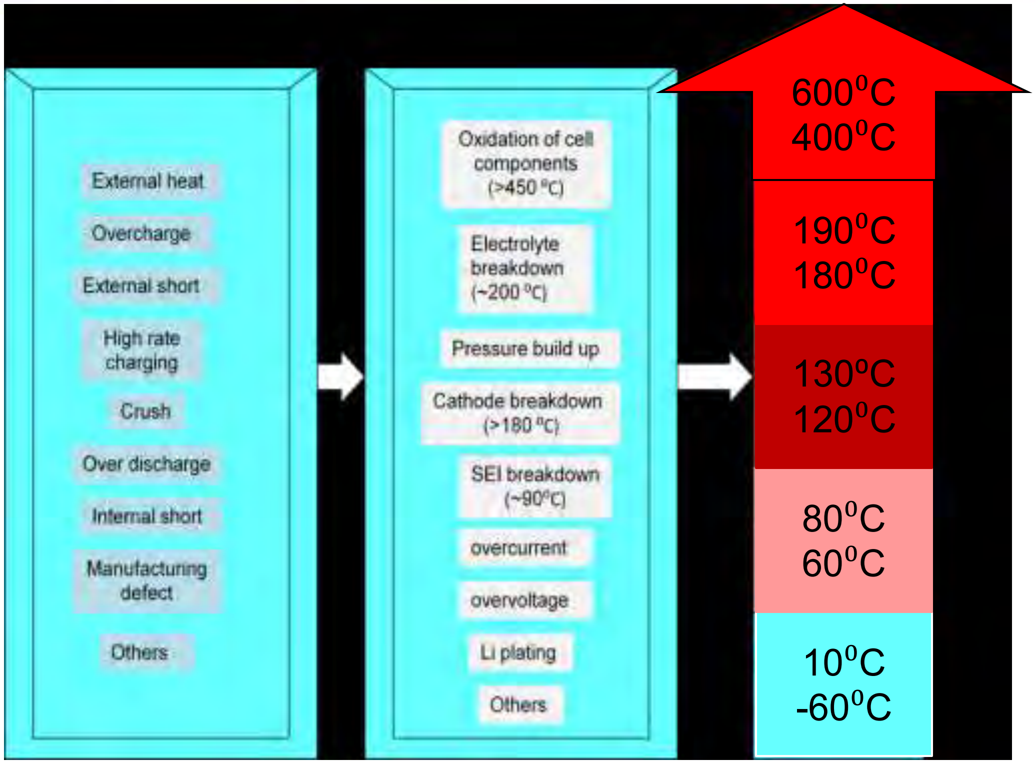
Li- Ion Battery Performance at Extreme Conditions

- **Low temperature operation (-40°C)**
  - Difficulty meeting startup requirements
    - Reduced power from increased impedance
  - Reduced discharge current and capacitance
  - Reduced charge acceptance/ Li Plating
  - ✓ Battery heater can be added
  - ✓ New electrolytes and additives are being developed

- **High temperatures operation (70°C)**
  - ✓ Improves battery performance
    - Increased electrochemical reactions
  - Reduced lifetime
    - Increased corrosion
  - Increased safety hazard

- **Optimization**
  - ✓ Operating temp between 0-50°C
  - ✓ Uniformity within and between modules

Engineering Challenge - Safety



Transportation may trigger safety hazard

Field failure caused by usage, control, etc

Battery thermal runaway

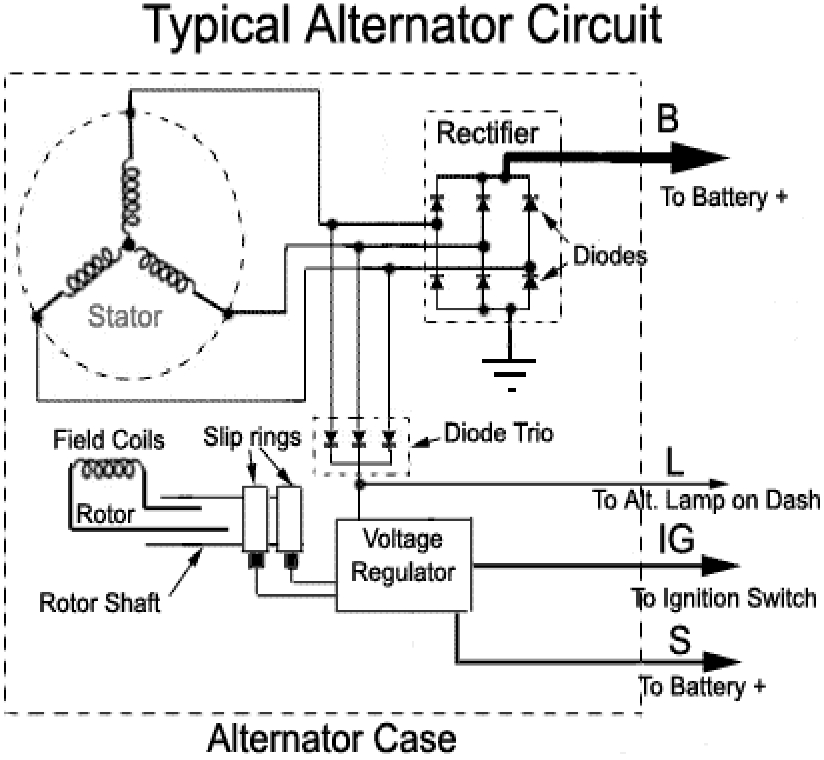
Battery Management System

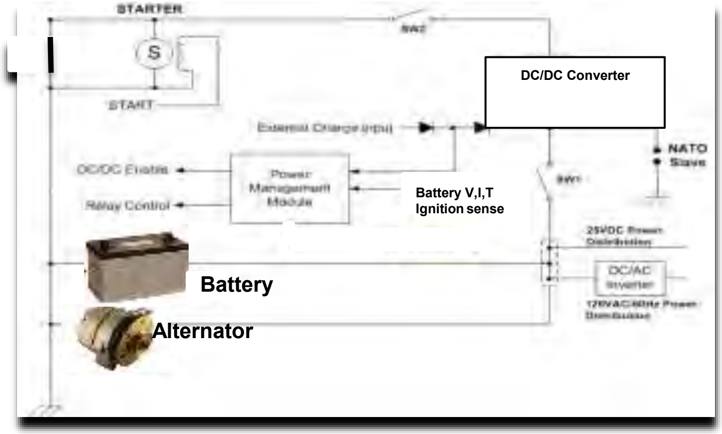
- **Needed to reduce safety hazard**
- **Required to increase battery life**
- **Monitors and reports**
  - State of Charge (SOC)
  - State of Health (SOH)
  - Voltage
  - Current
  - Temperature

- **Design challenges**
  - Handling transient spikes
    - Over-charge
    - Over-discharge
    - Over-current
  - Affordability
  - Varied charge/discharge methods
  - Communication interface
  - Battery self-discharge

Battery Charging

- The charge control for lithium ion battery chemistries is different from those of flooded and sealed lead acid batteries.
- The discharge control for lithium ion battery chemistries is different from those of flooded and sealed lead acid batteries.
- Battery charging voltage changes with the temperature





Challenge - Cost

- Current Lead acid battery: $50-$280/kWh
- Current Lithium ion battery: $800-$2000/kWh
- Long term target price for Li-ion battery is $500/kWh

Batteries represent one of the top ten ongoing maintenance costs in theater.

Conclusions

• The Li-ion battery replacement offers advantages due to the winning combination of energy and power density.

• Engineering challenges for Li-ion battery Replacement:

  ➢ Control
  ➢ Safety
  ➢ Cost
  ➢ Dual Applications

Quallion Matrix Battery Technology for Lithium-ion Lead Acid Replacement & Wide Operating Temperature Range Cells

May 2011

Powering Life.

Introduction

- Employing a core strategy of leveraging R&D, niche focus, complementary and synergistic market entries
- Largest manufacturer of Lithium cells in the U.S.
- Best-of-breed system level approach for advanced battery technologies involving a core expertise from material selection to cell design and final battery pack configuration
- Products:
  - Materials
  - Cells
    - Primary
    - Secondary
    - Polymer
  - Batteries
    - Matrix Battery (MBD)
  - Intellectual Property Portfolio
    - Zero-Volt
    - SaFE-LYTE
- End Markets
  - Aerospace
  - Defense
  - Medical
  - Utility
  - Vehicle

Headquarters:
Sylmar, CA

Founded
1998

Employees
161

Sites
Sylmar, California
Detroit, Michigan
New York, New York

Powering Life.

Targeting and Dominating Key Niche Markets

Quallion focuses on organic growth within niche markets rather than highly commoditized markets

Medical

Defense

Aerospace

Green Technology

Powering Life.

Overview of Battery Industry
Battery Market Stratification

QUALLION

Battery Market Stratification

Materials → Cell Design → Electronics → Battery Pack

Materials

Chemistries can be varied for high-energy, power, rate and capacity, safety.

Cell Design

Cell configurations include prismatic, cylindrical, flat stack, wound, large, small, polymer (pouch), hard case.

Electronics

Cell and battery management, power, safety, interface, communication (e.g., SM/CAN), balancing, state of health monitoring, modeling, grade of board parts.

Battery Pack

Pack design: safety, interconnects, spacing of cells, thermal gradients, heat ejection, environmental requirements, interface to application.

Powering Life.

Lithium-ion Challenges for Lead Acid Replacement

- Cost
  - Mitigated lifetime use, as long as lead acid is utilized for deep discharges
- Electronics
  - Battery must contain power electronics capable of high discharges while managing for external shorts
  - Safety for overcharge, overdischarge and over/under voltage
  - Charge management/regulation to ensure proper system function

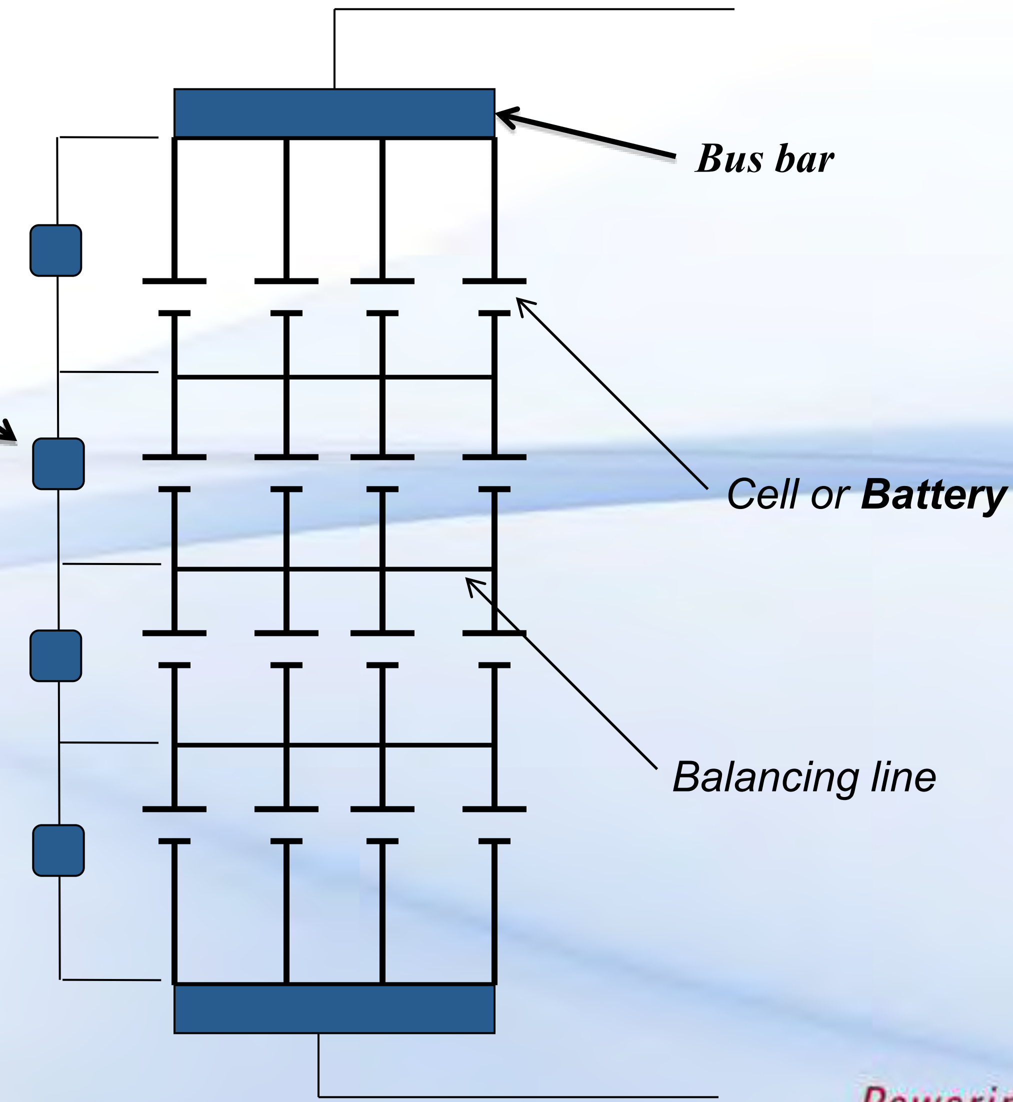
Quallion Matrix™ Technology

Powering Life.

Patented Quallion Matrix™ Battery Structure

Balancing Circuit or Connector to balancing circuit

Quallion Patents:
US7479346B1
US7573233B1
US7573234B1



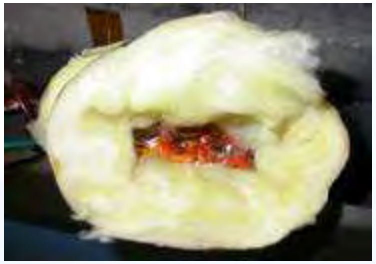
Powering Life.

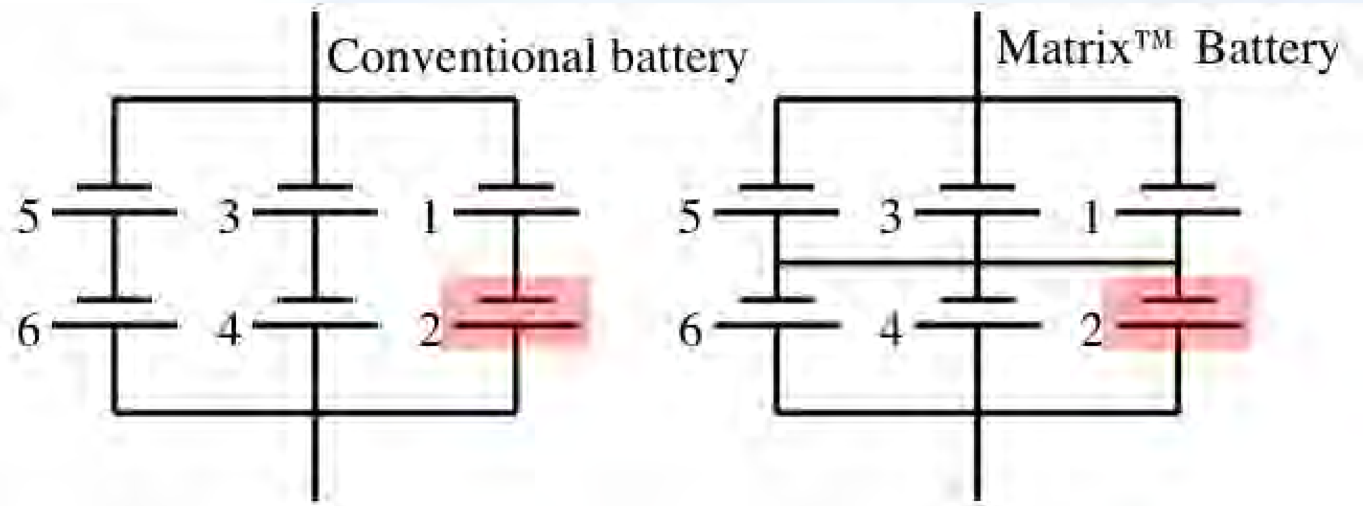
Quallion Matrix™ Technology
Safety Aspects

Powering Life.

Matrix™ Battery: Advanced Safety Feature

Cell : 18650





Apply local heating (>250°C) to Cell No.2

Conventional Battery:
Thermal Run-away Propagated to Entire Battery

Powering Life.

QUALLION

Matrix™ Battery: Thermal Run-away Localized to Only Cell #2

Powering Life.

Matrix™ Battery: Cell #3-6 Remain Functional

Cell number	Resistance (Ohm)	Voltage (V)
1	5600	-
2	-	-
3	0.04	4.14
4	0.026	4.107
5	0.03	4.14
6	0.03	4.08

QUALLION

Partial Penetration Test Conditions

- The module was charged with 53.3V, 3.5A (CCCV method) at room temperature (approximately 25 Deg C).
- The module was charged to 100% RSOC (reported by SMBUS communication).
- The module was penetrated with a 10 mm mild steel (conductive) pointed rod.
- The rate of penetration was approximately 8 cm/sec.
- The module was penetrated twice, once at the center of the outer cell and a second penetration between two outer cells.
- After penetrating the battery module, the test was monitored for one hour.

Powering Life.

Partial Penetration Test Results

Penetration at the center of the cell.

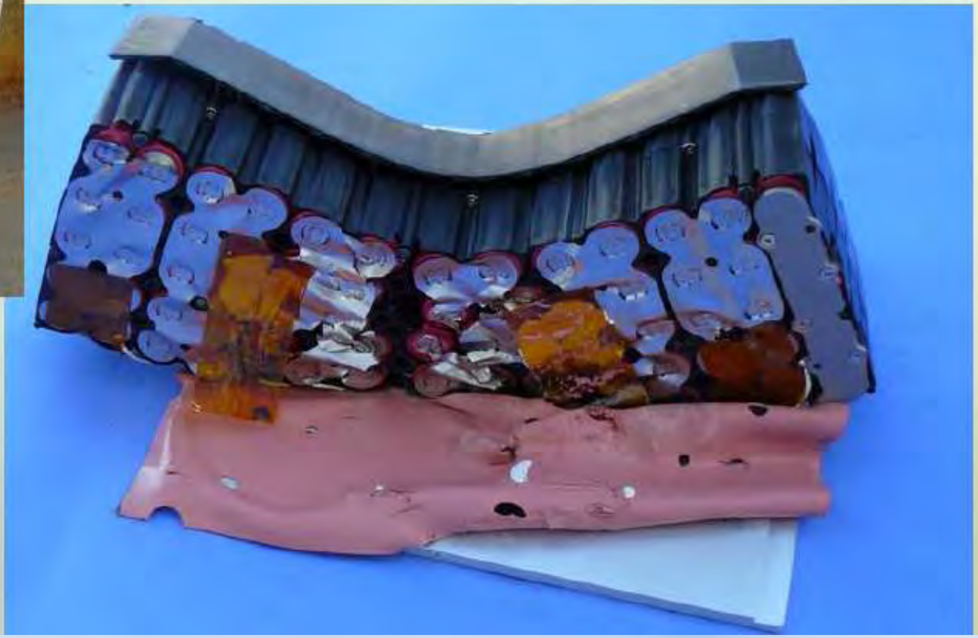
Penetration was between two adjacent cells.

0905865.000 A0T0 0110 R010

Crush Test Conditions

- The module was charged with 53.3V, 3.5A (CCCV method) at room temperature (approximately 25 Deg C).
- The module was charged to 100% RSOC (reported by SMBUS communication).
- The module was crushed between a flat plate and a textured plate as shown.
- Bottom flat plate was electrically isolated from the crush fixture.
- The crush occurred in two stages. In the first stage, crush is applied for 15% of the module's height, which is held for five minutes.
- In the second stage, crush was limited by a 47% displacement of the module's height and is held for five minutes.
- The module was observed for one hour after the test.

Crush Test Results



Powering Life.

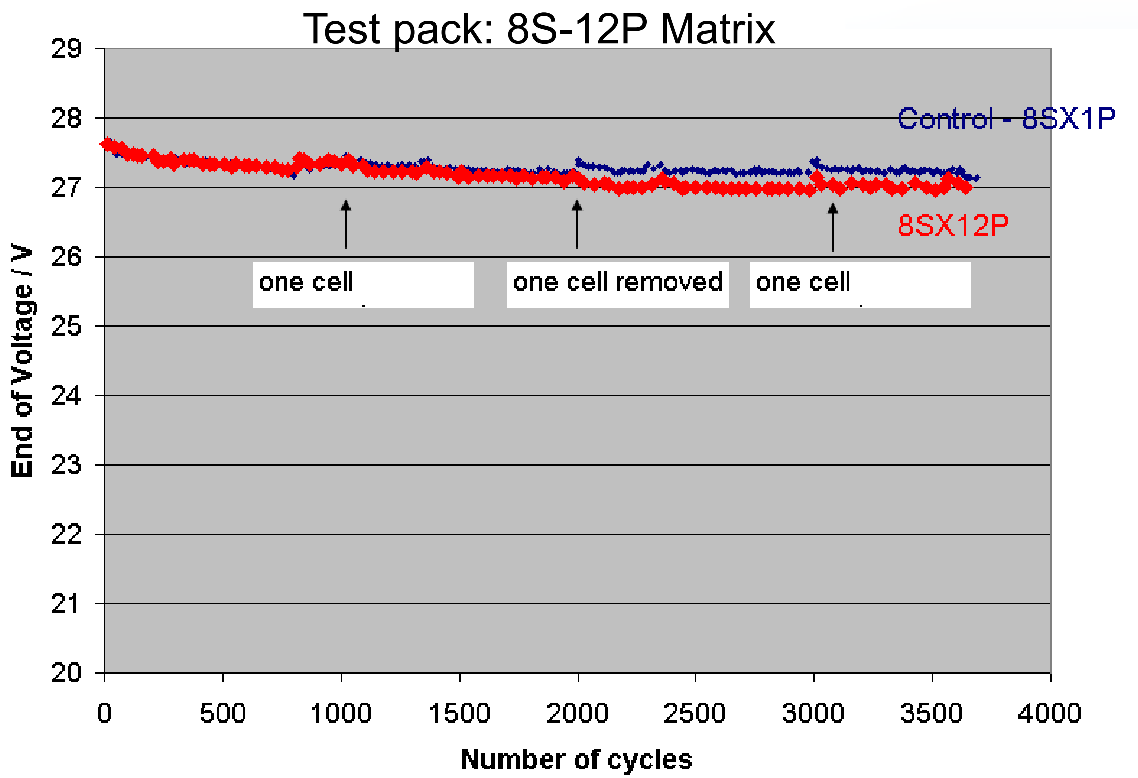
Qualion Matrix™ Technology Survivability

Powering Life.

Increased Load Test on Matrix™ Battery

…*A cell was removed at every 1000 cycles from pack*

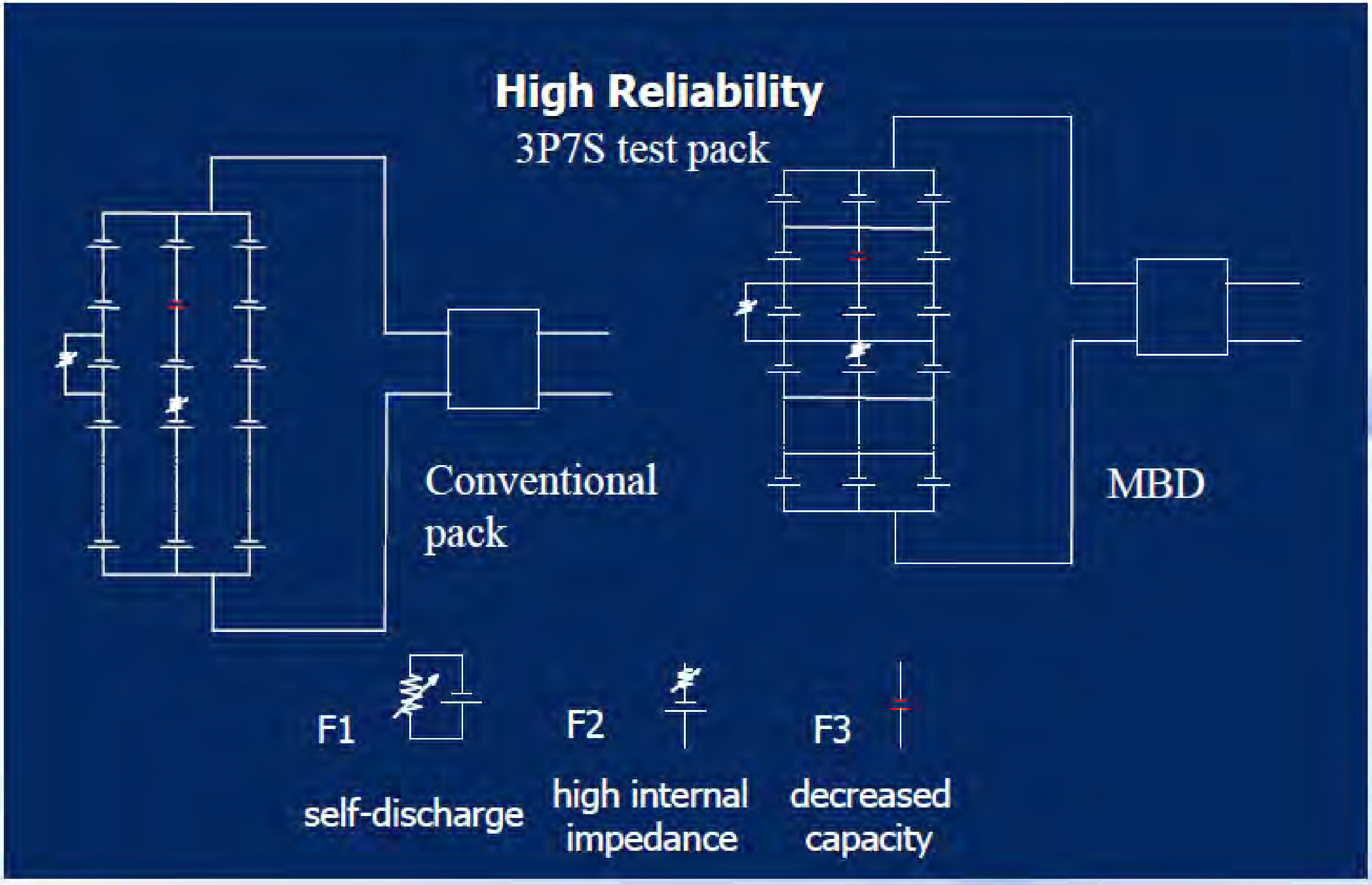
LEO cycle continued with no impact on battery voltage after 3750 Cycles with Three Failed Cells



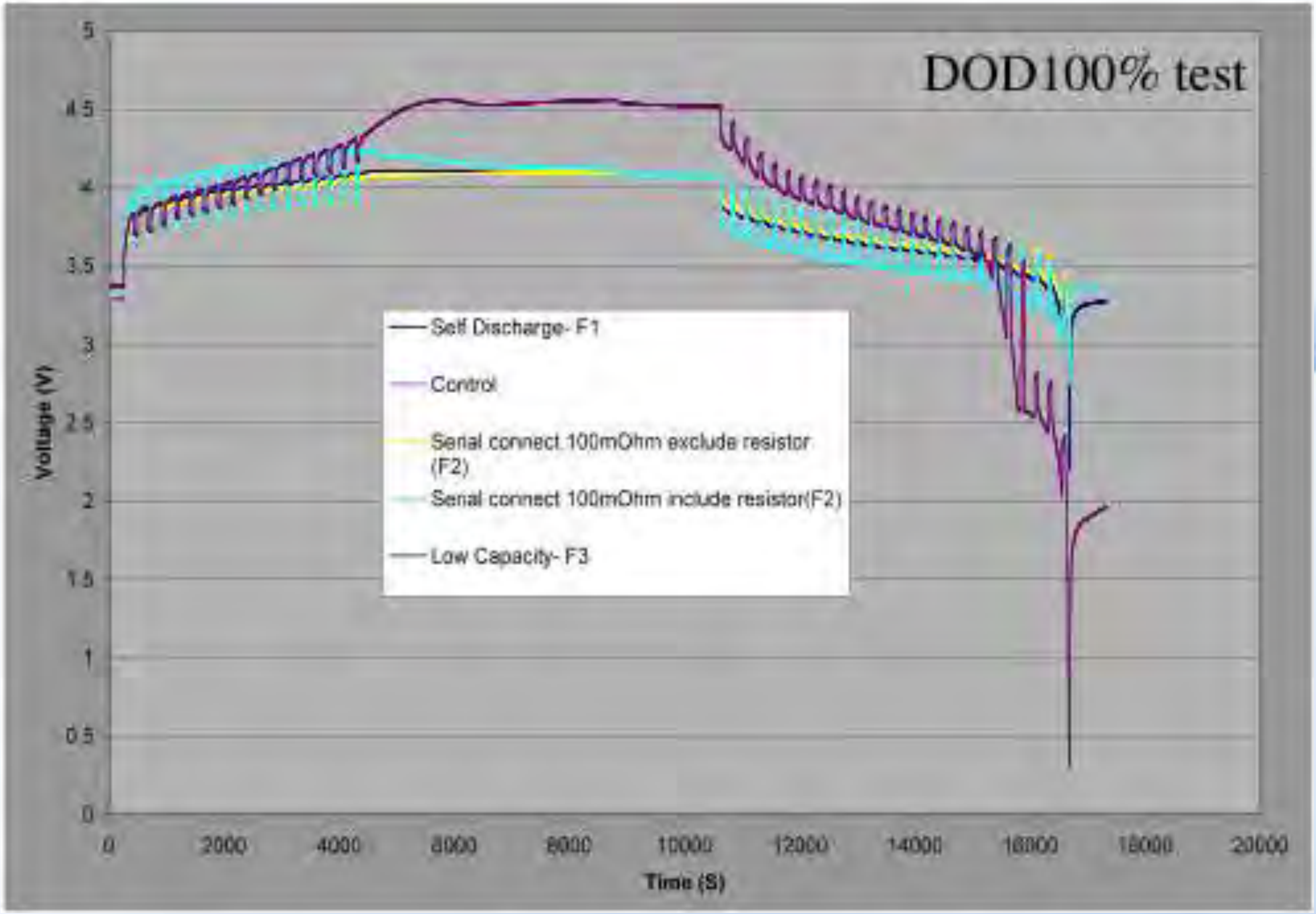
Test Parameters
- 90-minute orbit
- Charge at 6 A to 32 V clamp with a taper to end of the charge period of 60 minutes
- Discharge current 9.6 A for 30 minutes
- DOD: 40%
- Removed one cell at 1000th cycle, second at 2000th cycle and the third at 3000th cycle; to understand the performance of the battery with three failed cells

Powering Life.

Survivability Comparison: Matrix^{TM} vs. Conventional

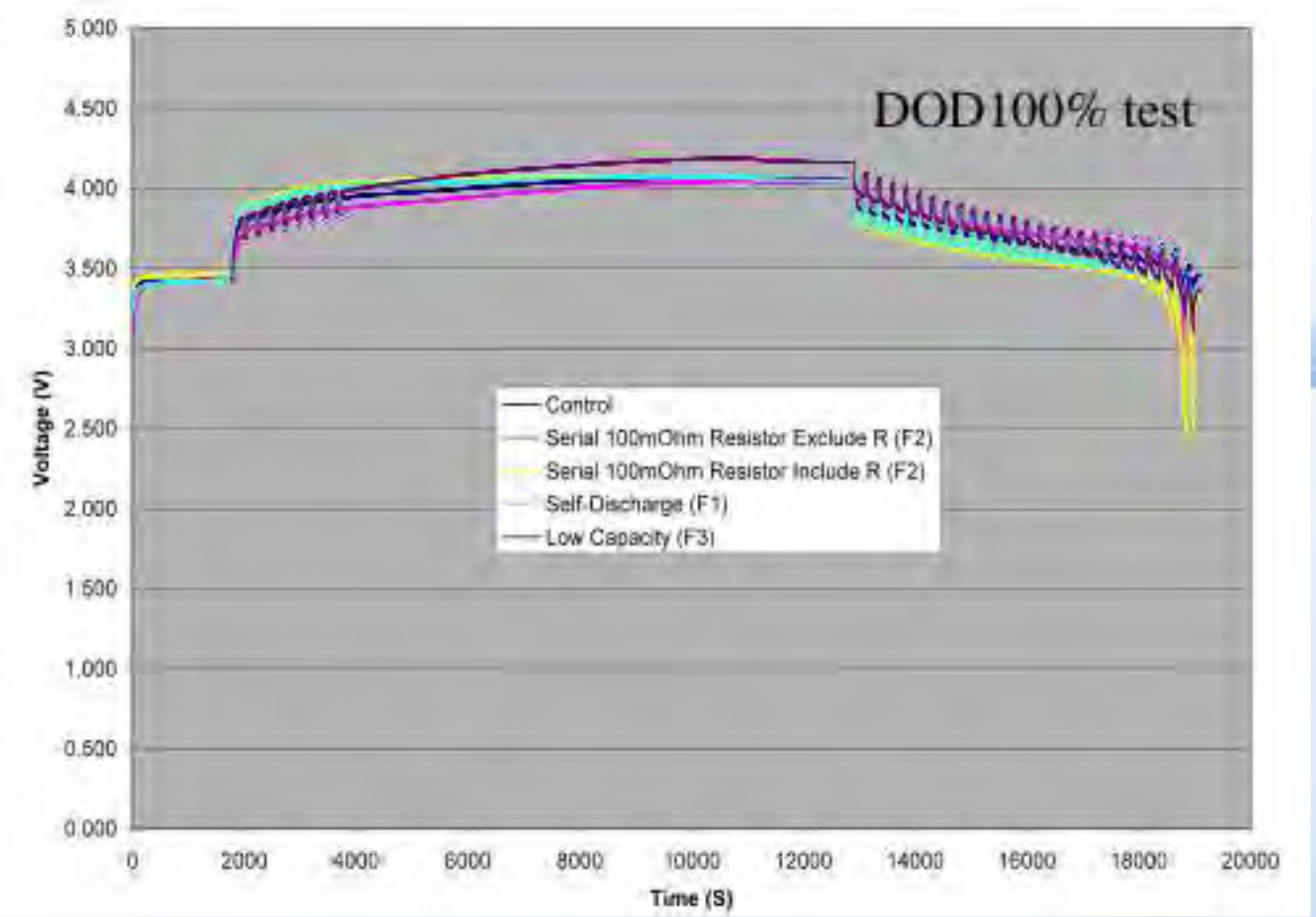


Conventional Pack: Failed in Overcharge at First Cycle



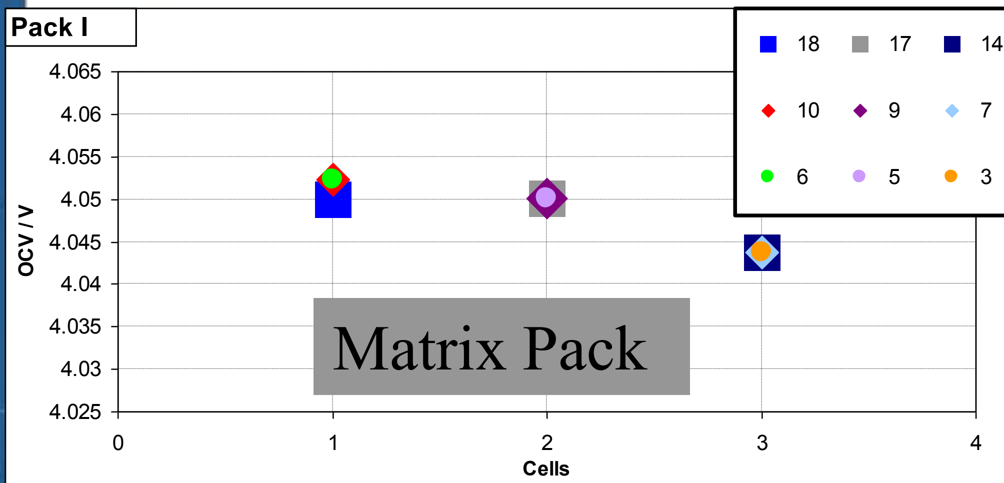
Powering Life.

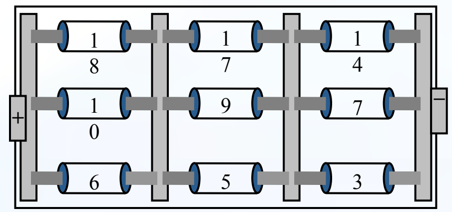
Matrix™ Battery:
No Overcharge & Survived an Additional 19 Cycles

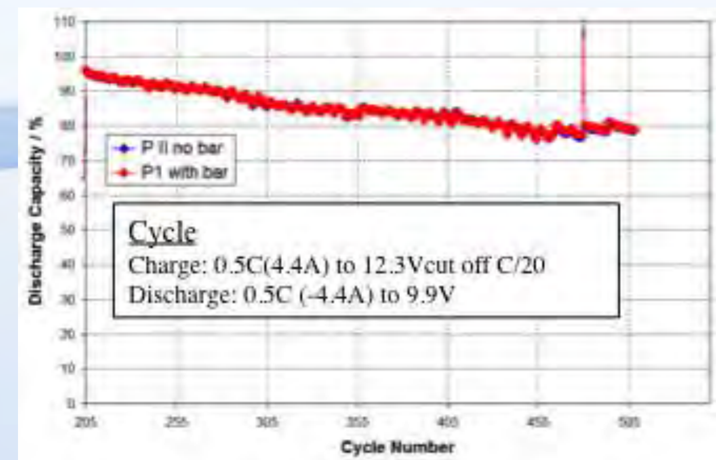


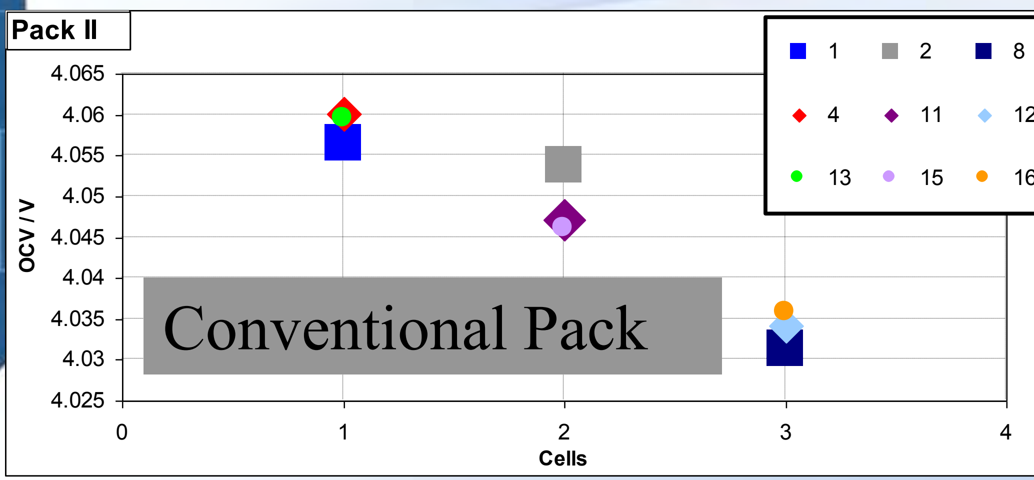
Powering Life.

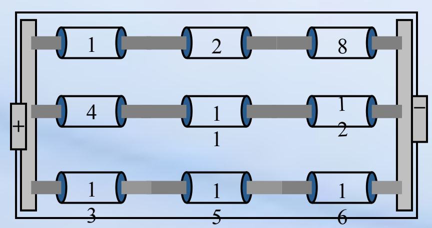
Matrix™ Battery: Less Balancing Need for Pack after 300 Cycles











Powering Life.

Matrix™ Battery: Flexible Power/Energy Ratio

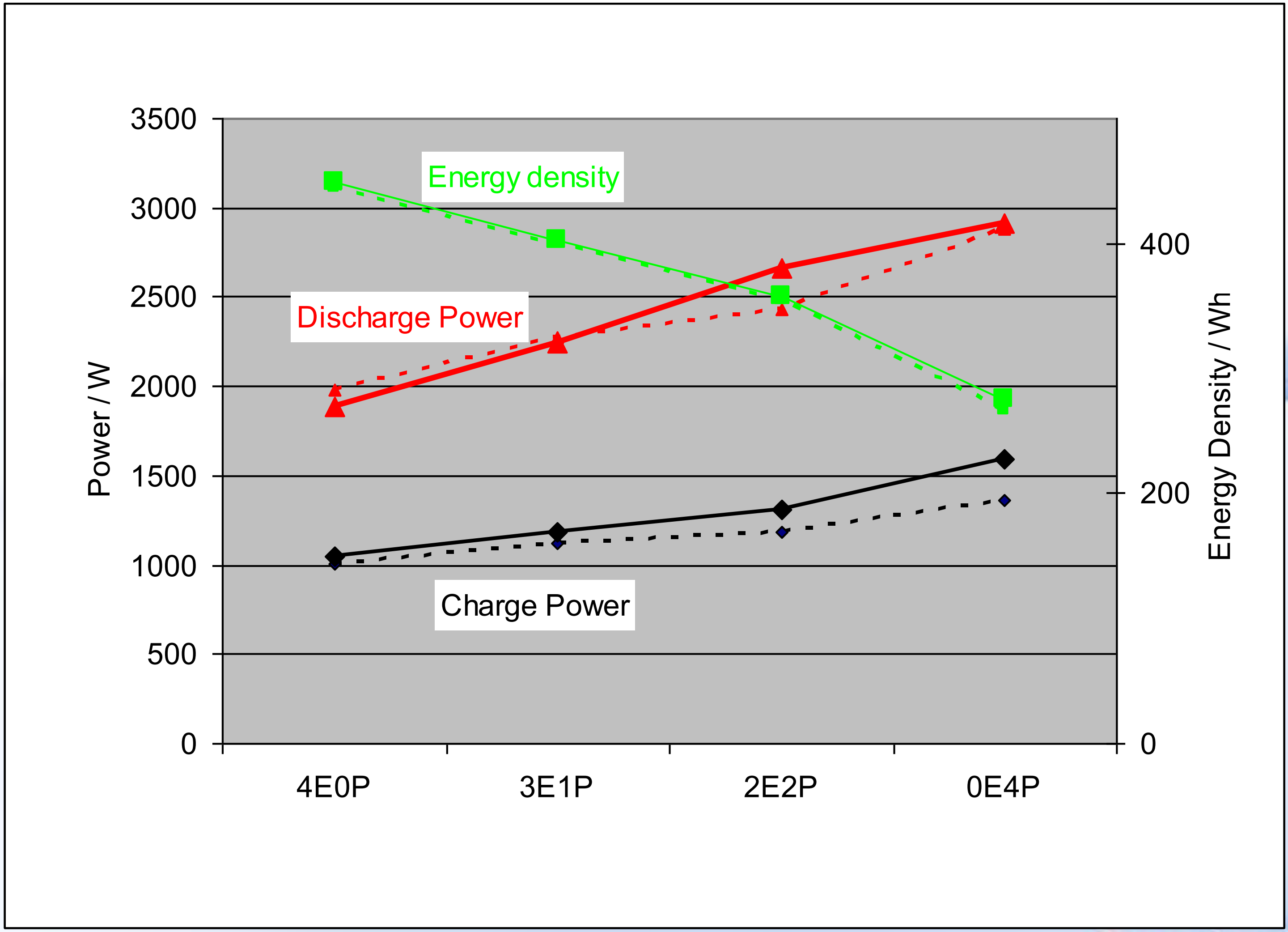
12S-4P with various HE/HP cell Mix

	HP Cells	HE Cells
Energy density	120Wh/kg	200Wh/kg
Power density	1000W/kg	200W/kg

Battery pack	Total number of cells	High power cells (18650 - 1.5 Ah)	High energy cells (18650 - 2.5Ah)	Weight (g) (including heat shrink tube, excluding tab)
4E0P	48	0	48	2208
3E1P	48	16	32	2176
2E2P	48	24	24	2160
0E4P	48	48	0	2112

12S-4P Hybrid Quallion Matrix™ Battery

… A matching correlation between design and performance

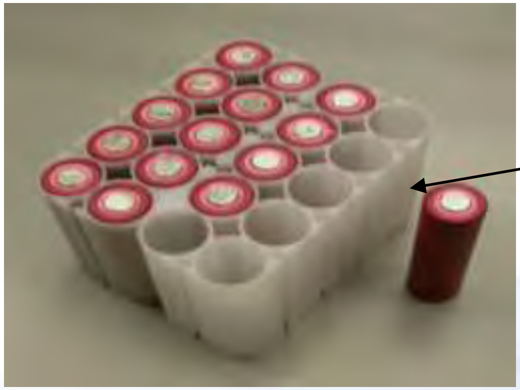


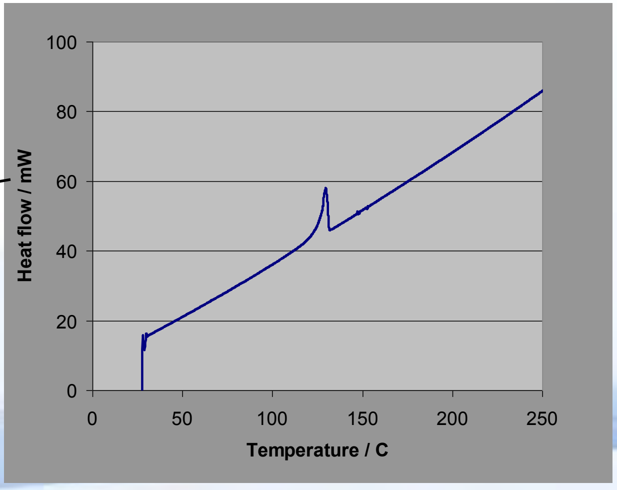
Powering Life.

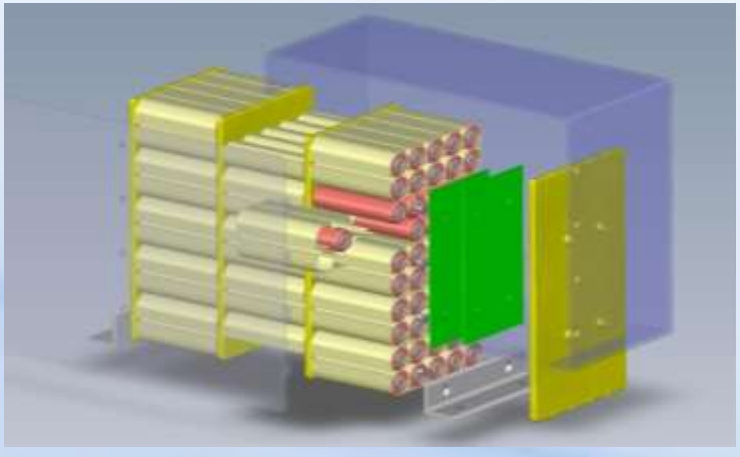
Quallion HAM™ Technology

Powering Life.

Quallion Heat Absorption Material (HAM™)Technology







Powering Life.

Overcharge Test with and without HAM™

Test Battery

18650 (1.5Ah high power) - 10 cells in Parallel connection.

Capacity- 15.0 Ah

with HAM sleeve

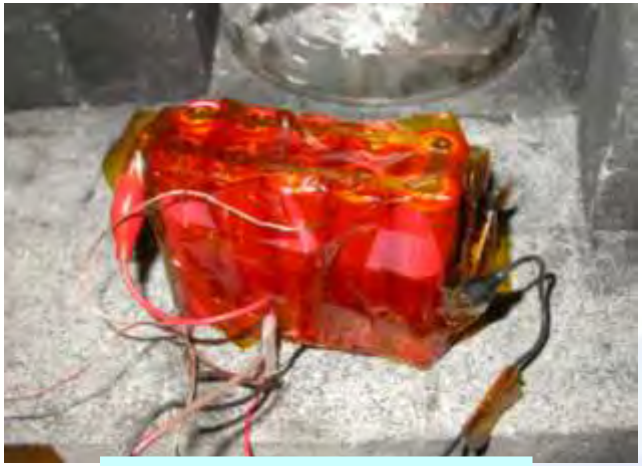
Overcharge Test Condition

Charge battery pack @6A to 12V, hold voltage @12V till temperature dropping

without HAM sleeve

Powering Life.

Thermal Run-away Propagation without HAM™



Connection

After Test

Insulation

After Test

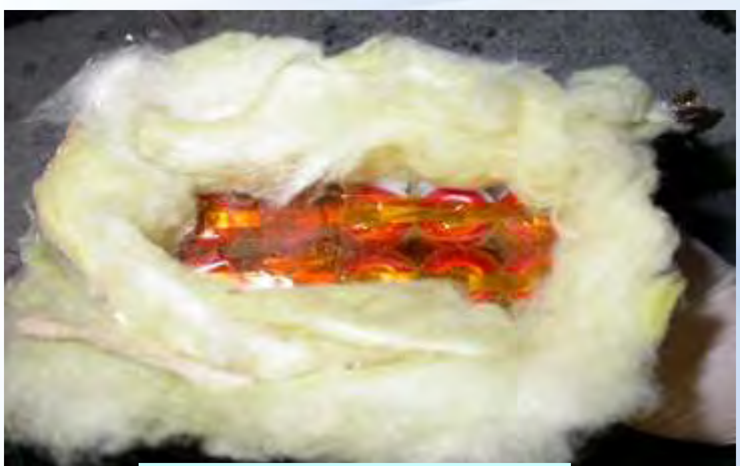
Powering Life.

Thermal Dissipation with HAM™

HAM™ melted and latent heat stopped thermal run-away

Connection

After Test



Insulation

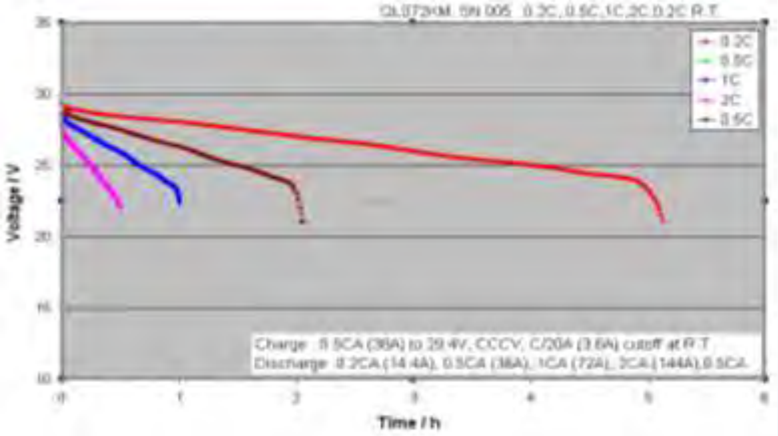
After Test

ering Life.

Quallion Matrix™ Technology In Large Lithium-ion Lead Acid Replacements

Powering Life.

Qualion 24V, QL072KM 1250A Capable Battery System for HMMWV



Discharge time at various rates

Current Lead-Acid Battery
12V x2Series, 65Ah, 59lb x2

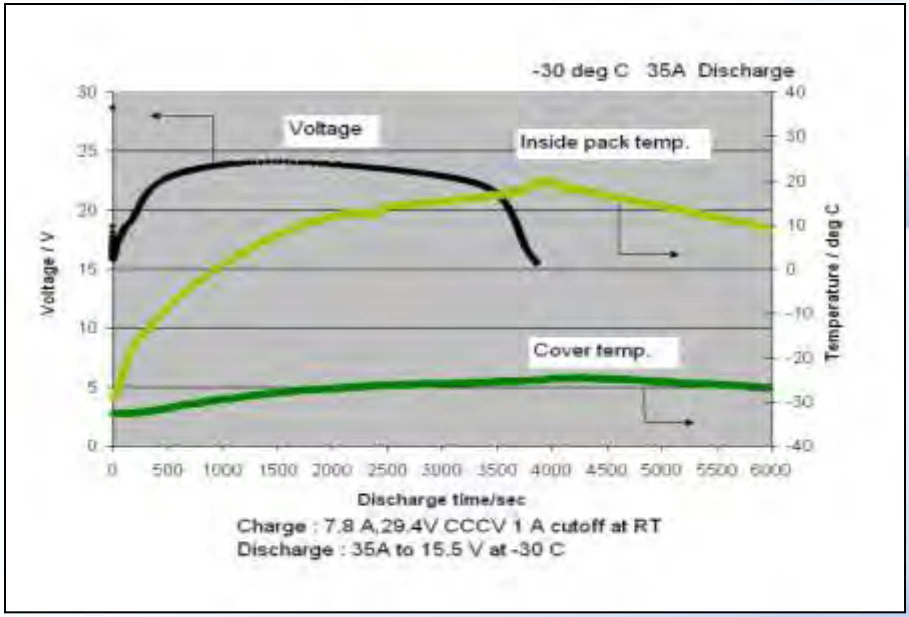
Quallion Drop-in Li-ion APU with Safety Circuit and Fuel Gauge
24V, 72Ah, 42lb

Powering Life.

24V, 50Ah Lithium-ion Battery for U2 Vehicle

Li-ion Tech Demonstration Unit using QL038KM unit

- 38 Ah capacity
- Flight Demonstration Fall 2008 with future scale up to 50Ah



QL038KM -30°C, 30A discharge (discharged 98% of nameplate capacity)

24V, 8.25Ah Lithium-ion EBPS for C-17 Aircraft

Qualification Program to Replace Current Ni-Cd System

- Low maintenance & long life
- Fully integrated charge control electronics, battery management electronics & BIT/SOC capability
- -65ºF to 160ºF (with heaters)
- 8.5lbs
- Full charge in 75 minutes over 21V to 32V input range
- Plug-N-Play

24V, 38Ah Lithium-ion Battery for Little Bird, MH-47 & MH-60 Vehicles

- 24V Lithium-ion/Lead Acid Replacement
- 1100 amp pulse capability
- 38 Ah capacity
- 24 lbs

QUALLION

Wide Operating Temperature Cell Designs

Powering Life.

Quallion Q18650-HP

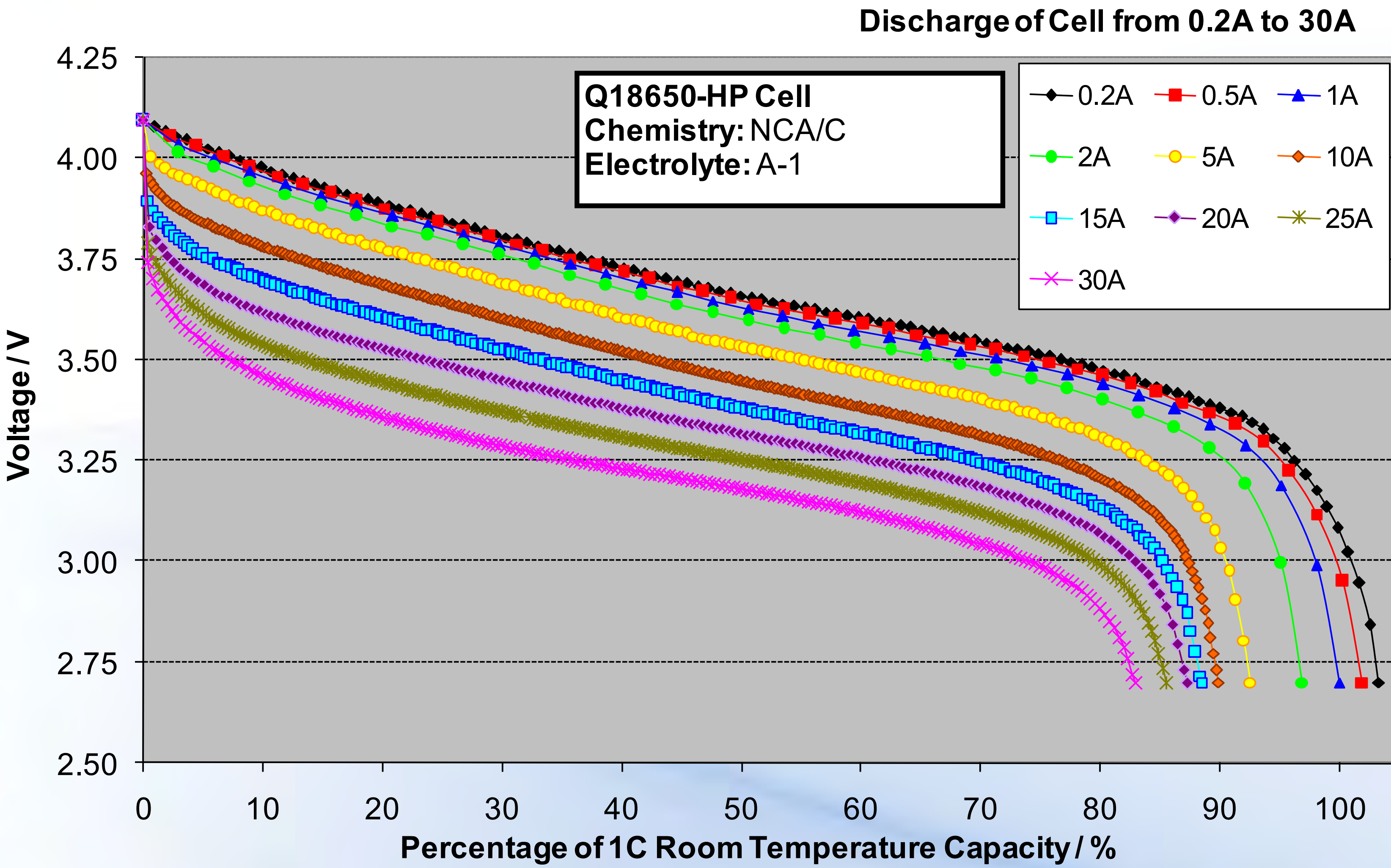
At -40°C, 30C rate discharge capable

Cell Specifications	
True Capacity / mAh*	1000
Energy Density / Wh/kg*	92
Energy Density / Wh/l*	217
Dimensions / mm	65 x 18 (H x d)
Weight / g*	39 ± 0.75

* Calculated values based on design

- **Operating Range** = -40°C to +71°C
- **Heritage Materials**
  - Active materials are the same as Quallion SATELLITE cells

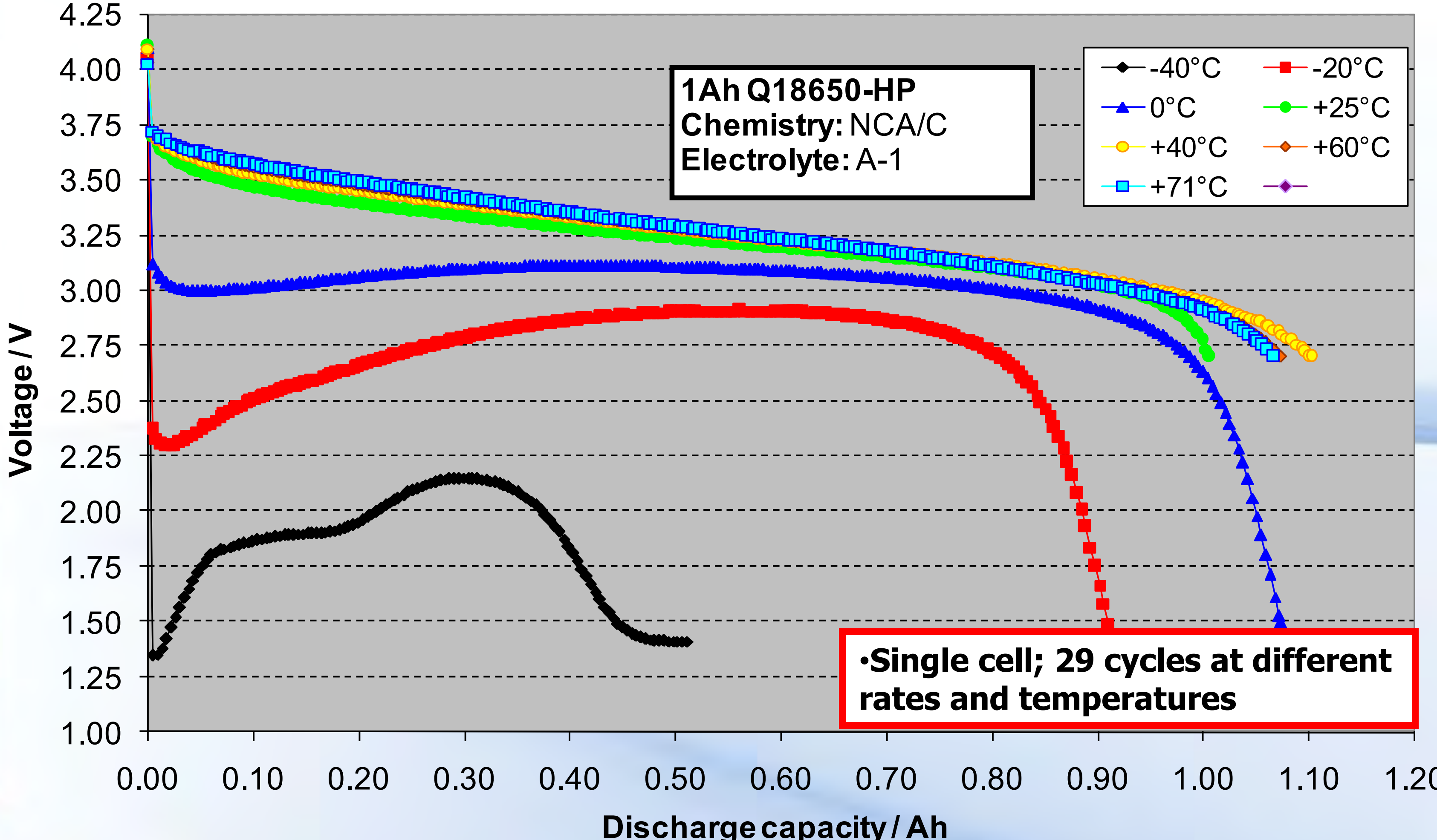
Discharge Rate Data of Quallion HP Cell



Charge : 1.0A, 4.1V CCCV C/20 mA cutoff at RT
Discharge : 0.2, 0.5, 1, 2, 5, 10, 15, 20, 25, 30A to 2.7 V at RT

Powering Life.

Discharge Temperature Data of Quallion HP Cell at 30C Rate



Charge : 1.0A, 4.1V CCCV C/20 mA cutoff at RT
Discharge : 30CA to 1.5V at -40 , -20 , 0 C or 2.7V at RT, +40 , +60 , and +71 C

Powering Life.

Qualion High Power 2.3Ah Cell

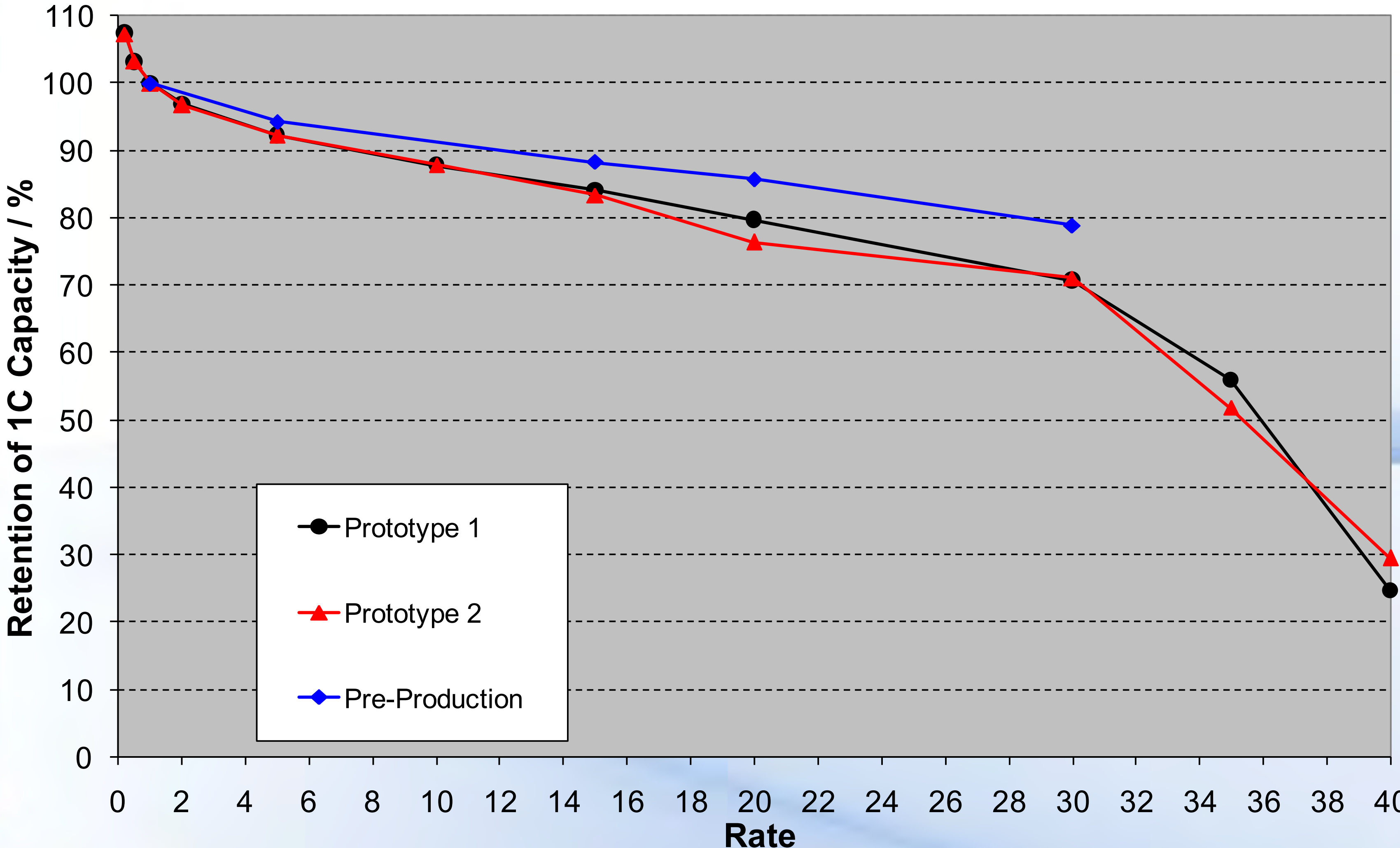
- Dimensions (without tabs) – 5.5” x 2.25” x .25”
- Weight – 75g

Pouch Cell

Cell Specifications	
Rated Capacity / mAh*	2300
Energy Density / Wh/kg*	110
Energy Density / Wh/l*	205
Dimensions	5.3 x 2.1 x 0.25 (H x W x T)
Weight / g	75 ± 0.75

- **Operating Range** = -40°C to +70°C
- **Heritage Materials**
  - Active materials are the same as Quallion SATELLITE cells
  - USG T3 program enables Quallion to produce Cathode and Anode material in-house by 2012

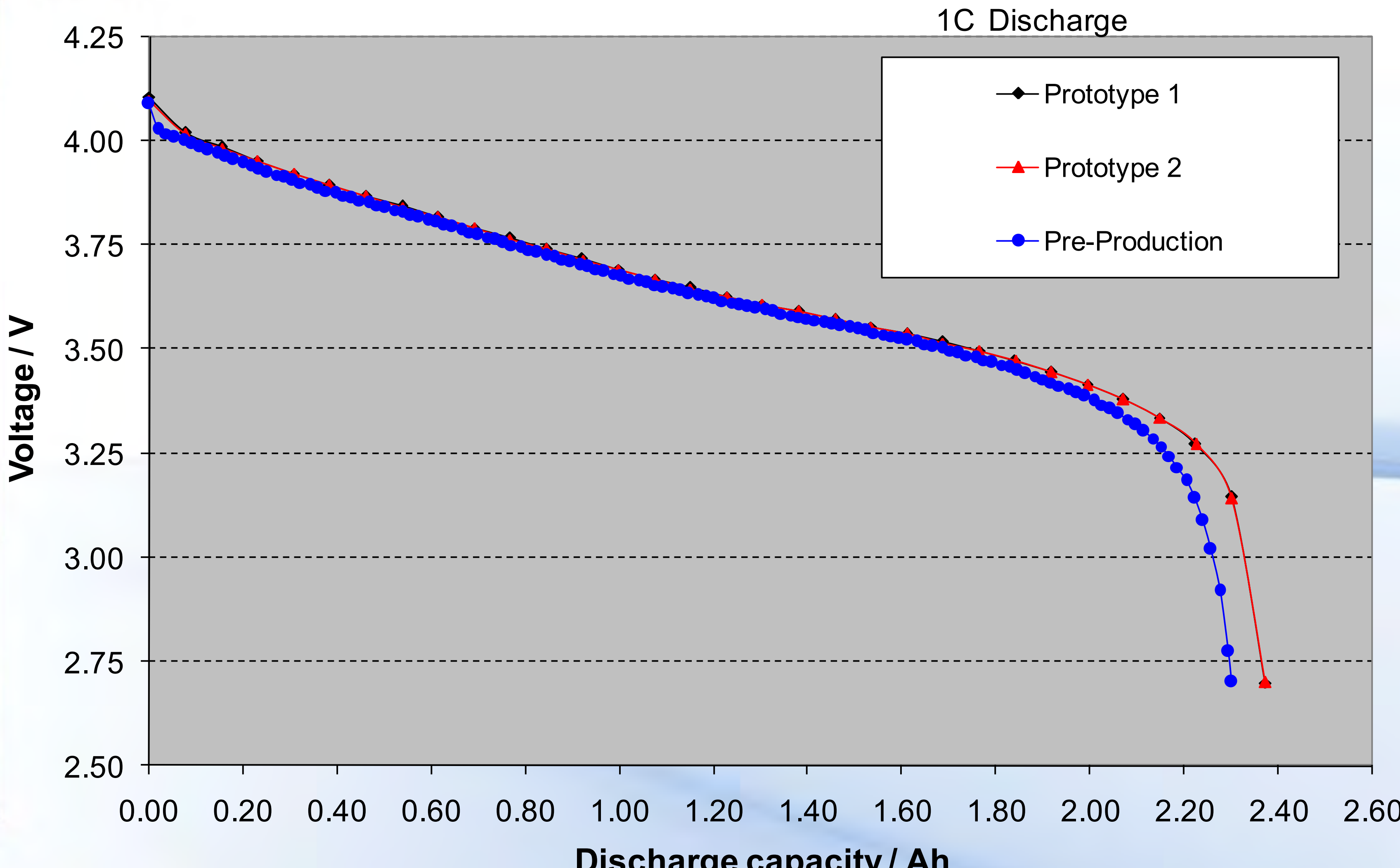
Rate Test Summary at RT



Charge : 1.0C A, 4.1V CCCV C/20 mA cutoff at RT
Discharge : 0.2, 0.5, 1, 2, 5, 10, 15, 20, 25, 30C A to 2.7 V at RT

Powering Life.

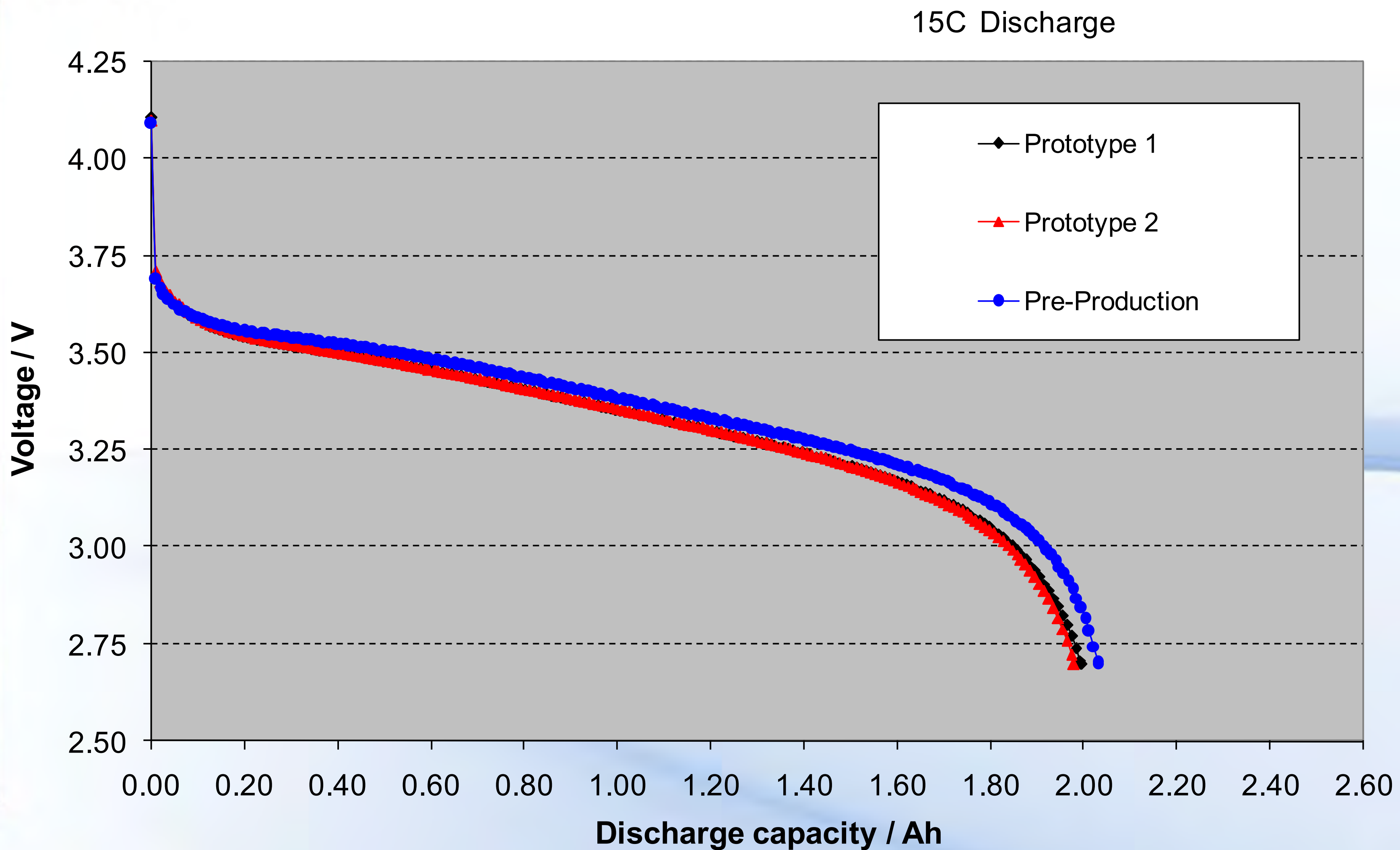
1C Discharge Rate Curve at RT



Charge : 1.0 CmA, 4.1V CCCV C/20 mA cutoff at RT
Discharge : 1 CmA to 2.7V at RT

Powering Life.

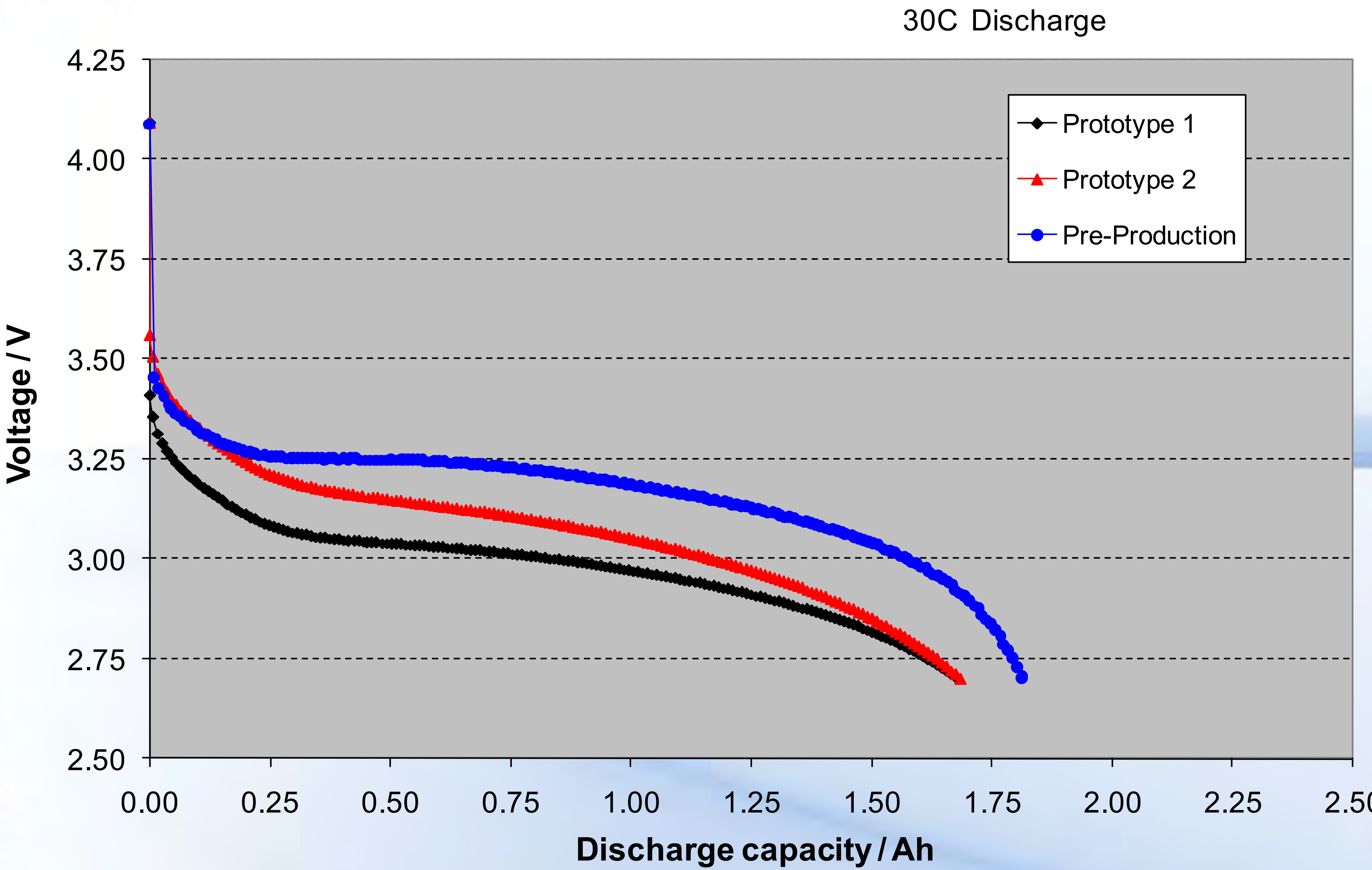
15C Discharge Rate Curve at RT



Charge : 1.0 CmA, 4.1V CCCV C/20 mA cutoff at RT
Discharge : 15 CmA to 2.7 V at RT

Powering Life.

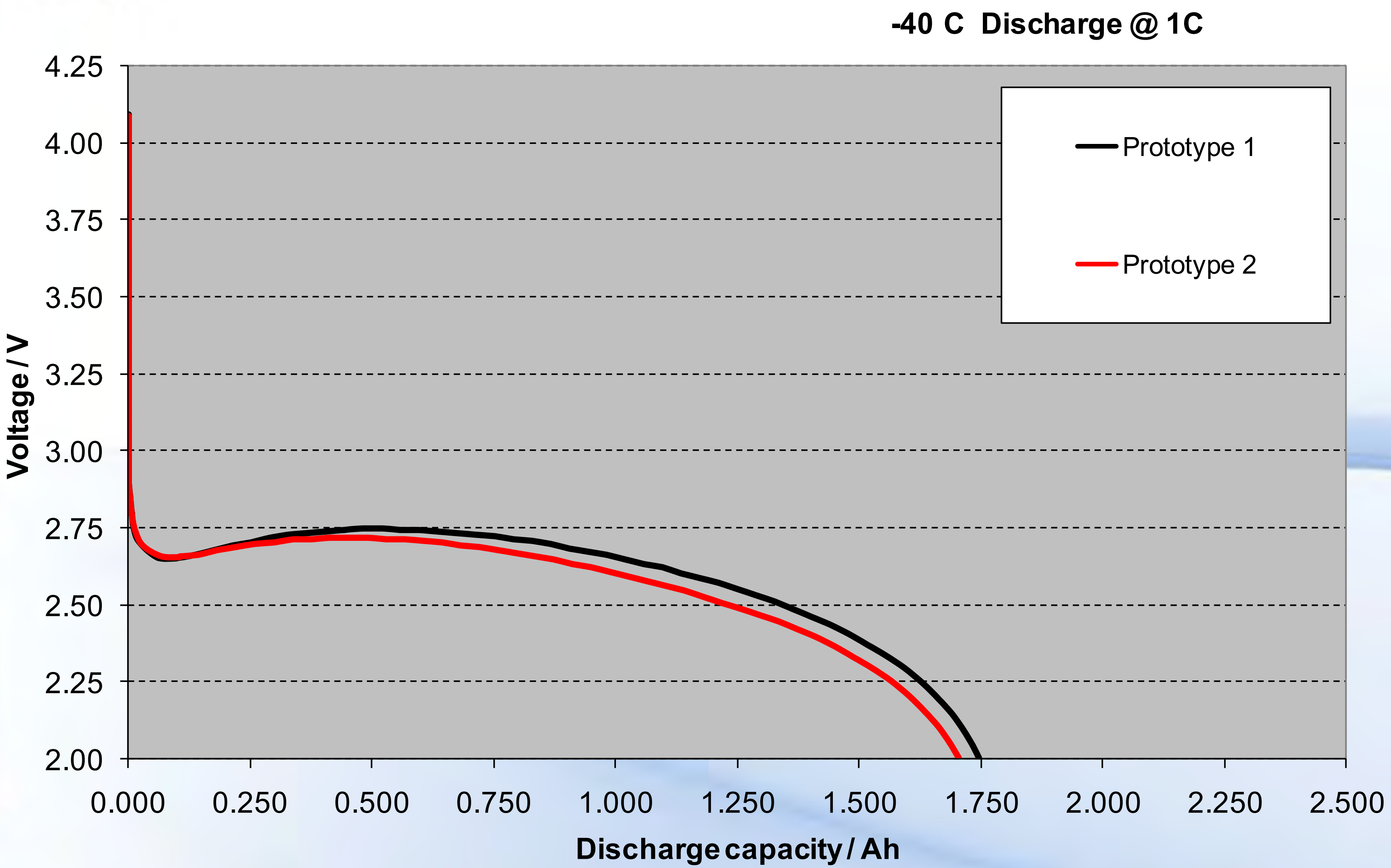
30C Discharge Rate Curve at RT



Charge : 1 CmA, 4.1V CCCV C/20 mA cutoff at RT
Discharge : 30 CmA to 2.7 V at RT

Powering Life.

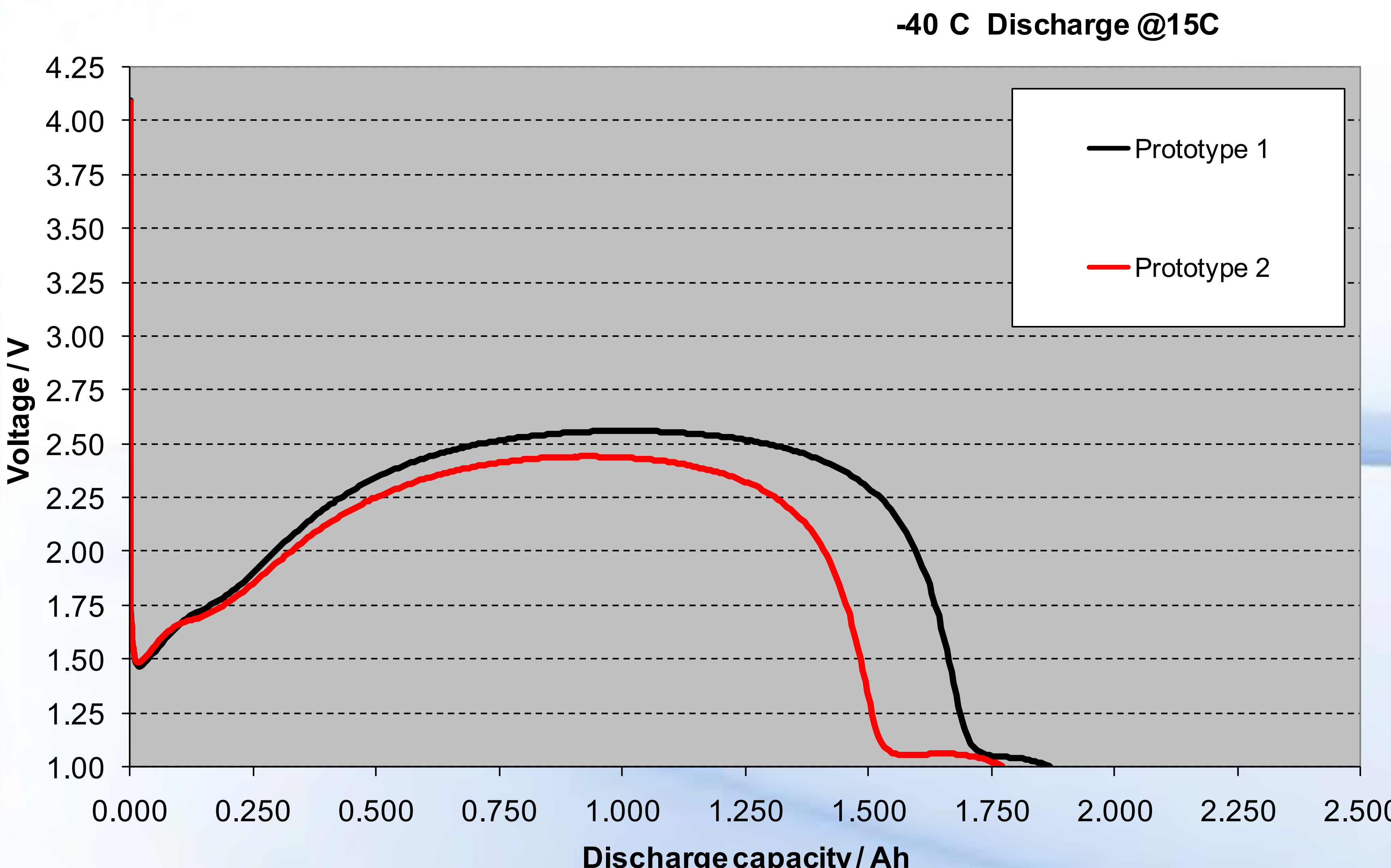
1C Discharge at -40°C



Charge : 1 CmA, 4.1V CCCV C/20 mA cutoff at RT
Discharge : 1 CmA to 1.5 V at -40 C

Powering Life.

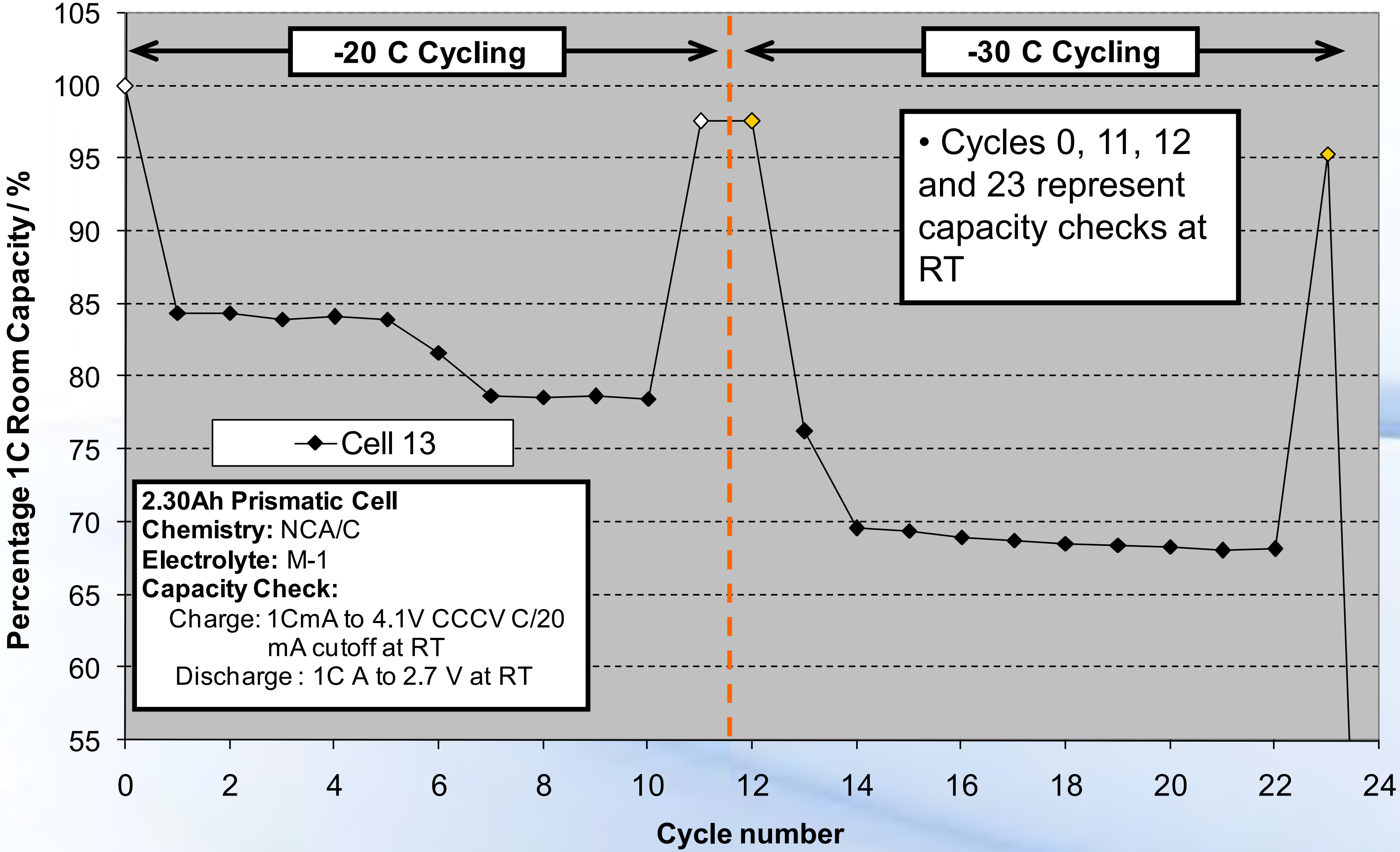
15C Discharge at -40°C



Charge : 1 CmA, 4.1V CCCV C/20 mA cutoff at RT
Discharge : 15 CmA to 1.0 V at -40 C

Powering Life.

C/2 Charge/Discharge Cycling of Prismatic Cell at -20° & -30°C



Charge : C/2 A, 4.1V CCCV C/50 mA cutoff at -20 & -30 C
Discharge : C/2 A to 2.5 V at -20 & -30 C

Powering Life.

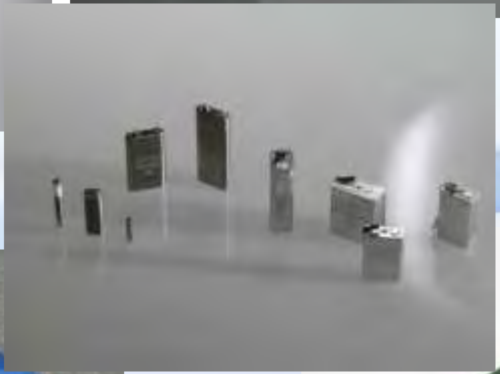
Quallion 10Ah Cell with Wide Operating Temperature

Cell Specifications	
Theoretical Capacity / mAh*	10000
Energy Density / Wh/kg*	82
Weight / g*	450

* Calculated values based on design

- **Operating Range** = -40°C to +71°C
- **Heritage Materials**
  - Active materials are the same as Quallion SATELLITE cells
  - Wide temperature electrolyte
- **5000 DOD 60% to 80% Cycling over Wide Temp Temperature Spectrum**
- **Cell to undergo life testing February 2011**

QUALLION



Powering Life.

Vincent Visco | 818.833.2000 | vincev@quallion.com | www.quallion.com

Integration of Nanophosphate™ Prismatic Cells into the XM1124 Hybrid Electric HMMWV

Dr. Mike Marcel, PE
Tony Knakal
A123 Systems
Terry Stifflemire
Robert Lock
DRS Test and Energy Management
Sonya Zanardelli
Gus Khalil
US Army TARDEC

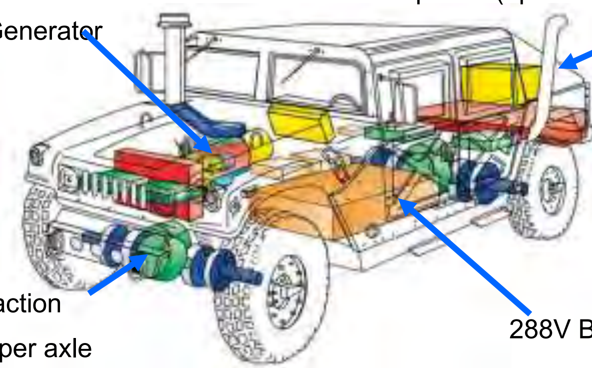
History

XM1124 Hybrid Electric HMMWV

A123 SYSTEMS

Description

- Replaces the conventional HMMWV drive train with a hybrid drive train while retaining the capabilities of the standard HMMWV
- Quiet, mobile platform for silent watch, reconnaissance missions
- Reduced thermal and acoustic signatures
- Power generation capability



Key Requirements

- *Provide 33 kW of continuous power*
- *C130 Transportability*
- Multi-phase mobile power (AC/DC)
- Maintain HMMWV capabilities; mobility, transportability, and payload.
- Two level maintenance
- Open Architecture for upgrades

DRS TECHNOLOGIES
A Finmeccanica Company

TARDEC

Why Hybrid Technology is Needed on Today's Battlefield

Manned or Unmanned Systems

Base Platform for Systems Approach development

<u>*Mobility*</u>

Equivalent mobility performance

Reduced Fuel Consumption

Delivers Utility Grade Power

Provides Silent Watch / Move

Mobile on-board power generation – <u>Power on the Move</u>

Reduced Logistic footprint

Payload Weight/Performance Trades

<u>*Power and Energy*</u>

Full Spectrum Energy Performance

Reduced Logistics Footprint with ripple effects across the theater

Supports Warrior Batteries

Reduced Maintenance and Personnel

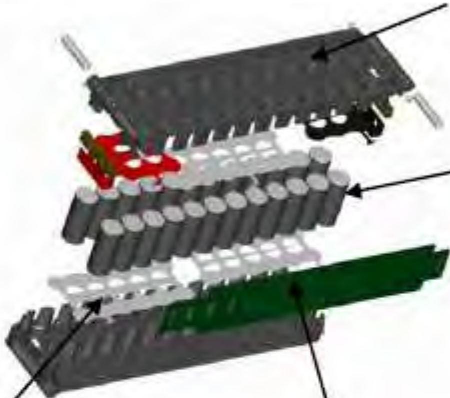
Provides Uninterruptible Power

Supports Integrated P&E Concepts

XM 1124 provides an immediate baseline for the assessment of energy centric hybrid vehicles and platforms -- Proves HE readiness for final development, and supports ONS/Requirements for the objective architecture

XM1124/A123 "Gen 1" Cylindrical Pack

Integrated and tested in 2008



A123 26650 Module

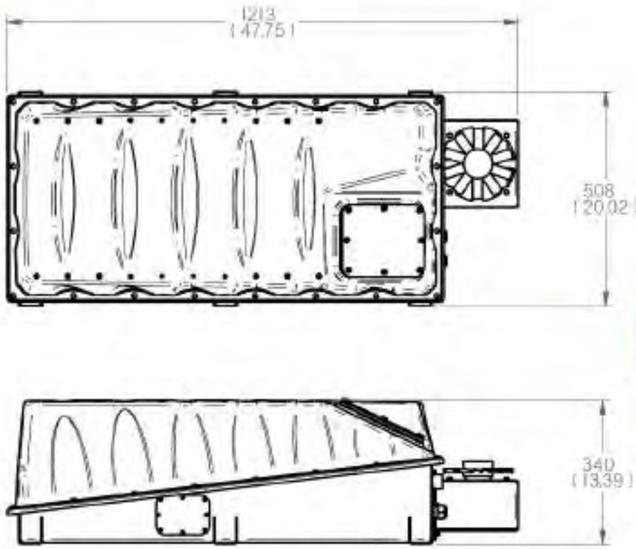
- Comprised of 24 – 26650 Cells
- Used as a "building block" for air cooled vehicle pack designs

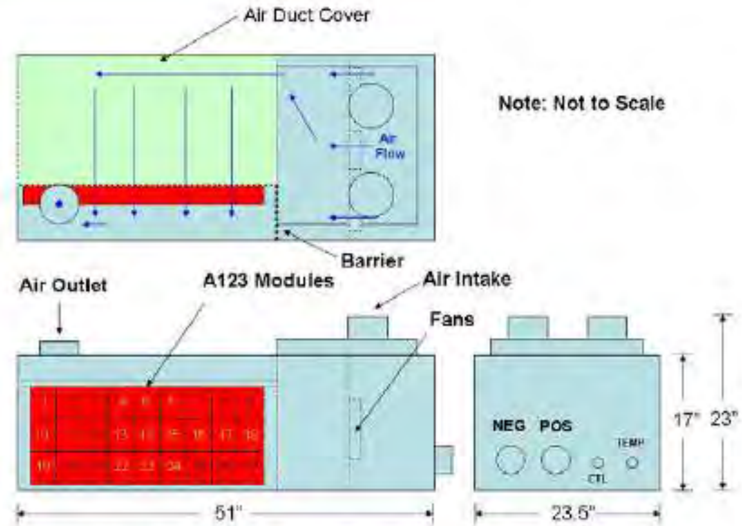
**Details of this pack design are in the proceedings of the 2008 NDIA Power and Energy Workshop*

Nominal capacity and voltage	2.3 Ah, 3.3 V
Internal impedance (1kHz AC)	8 mΩ typical
Internal resistance (10A, 1s DC)	10 mΩ typical
Recommended standard charge method	3A to 3.6V CCCV, 45 min
Recommended fast charge current	10A to 3.6V CCCV, 15 min
Maximum continuous discharge	70A
Pulse discharge at 10 sec	120A
Cycle life at 10C discharge, 100% DOD	Over 1,000 cycles
ecommended charge and cut-off V at 25°C	3.6V to 2V
ecommended charge and cut-off V below 0°C	4.2V to 0.5V
perating temperature range	-30°C to +60°C
storage temperature range	-50°C to +60°C
Core cell weight	70 grams

XM1124/A123 Gen 1 Cylindrical Pack

Integrated and tested in 2008





XM1124 Nanophosphate® Pack

XM1124 Based on A123 HD-100

Hybrid Energy Storage

- **100kW output power, 65kW input power**
- **350V nominal (250V-420V operating range)**
- **13.8Ah nominal capacity**
- **4.8kWh energy storage**
- **400A 10s max pulse**

A123 SYSTEMS

XM1124 “Gen 2” Battery Pack

Nanophosphate™ Technology

The Nanophosphate® Advantage

A123 SYSTEMS

Power

Superior power by weight or volume in a cost effective solution

- Fast charge capable
- Enables smaller, lighter battery pack
- Consistent power over wide state of charge (SOC) range for greater pack utilization

Safety

Nanophosphate® is stable chemically, providing the foundation for safe systems

- Superior safety and abuse tolerance compared to metal oxide lithium ion chemistries
- Independently validated by National Labs and multiple customers
- Multiple layers of protection at the chemistry, cell and system level mitigates risk

Life

Excellent calendar and cycle life with consistent performance over extended use

- Nanophosphate technology retains performance enabling less pack oversizing
- At low rates our cells can deliver thousands of cycles at 100% depth of discharge
- Energy and power capability retained over extended life
- High rate and deep cycling capabilities mean greater battery utilization

Energy

Higher useable energy means greater battery utilization and lower cost

- Deeper cycling and a wider usable SOC range means higher usable energy; more of the battery's energy can actually be utilized in the application.
- High usable energy enables less pack oversizing for superior price-performance

Superior Performance + Greater Battery Utilization = Price-Performance

Scalable Modular Architecture

A123 XM1124 "Gen 2" Battery Pack

Module sizes can be made to accommodate various customer solutions

Fully Automated process allows flexible module fabrication that results in a best overall value product

A123 Prismatic Cell

A123 SYSTEMS

Nanophosphate® AMP20*M1HD-A:* Designed for plug-in hybrid and electric vehicle applications, the AMP20 prismatic cell is built to deliver high energy and power density combined. The AMP20 cell demonstrates industry-leading abuse tolerance coupled with excellent life performance under the most rigorous duty cycles. The AMP20 delivers high useable energy over a wide state of charge (SOC) range to minimize pack oversizing and offer very low cost per watt-hour.

Power: Over 2,400 W/kg and 4,500 W/L

Safety: Excellent abuse tolerance and environmentally friendly

Life: Excellent calendar and cycle life

Nominal voltage: 3.3V

Nominal capacity: 20Ah

MODULARITY

COST

26650 Cell

Prismatic Cell

A123 Hybrid Vehicle Solutions

A123 XM1124 “Gen 2” Battery Pack

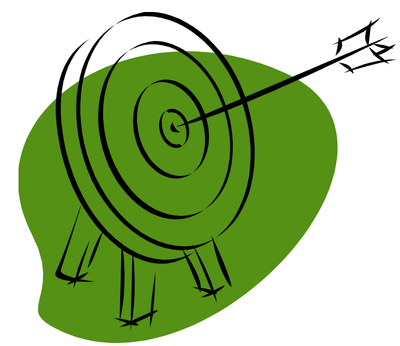
Prismatic Core Technology allows for cost effective total solutions

- Technology commonly used for EV/HEV packs
- Scalable Prismatic Module
- Battery Control Module (BCM)
- Electrical Distribution Module (EDM)
- Current Sense Module (CSM)
- Battery Management and Controls
- Pack Enclosure Systems with Integrated Cooling (if needed)

Prismatic Module

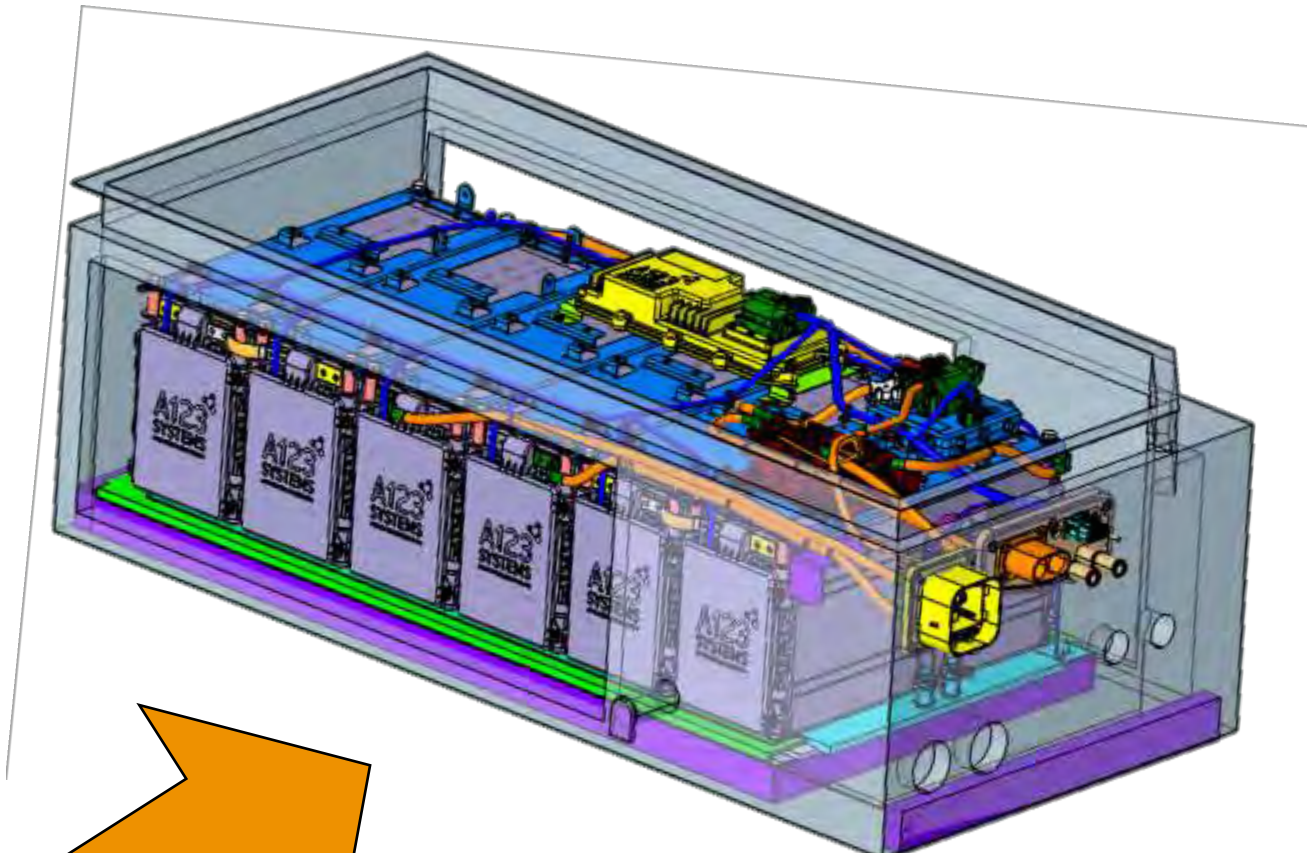
EDM+CSM

BCM



XM1124 Pack Upgrade

A123 XM1124 "Gen 2" Battery Pack



A123 prismatic modules integrated into existing XM1124 battery tray

Pack Characteristics

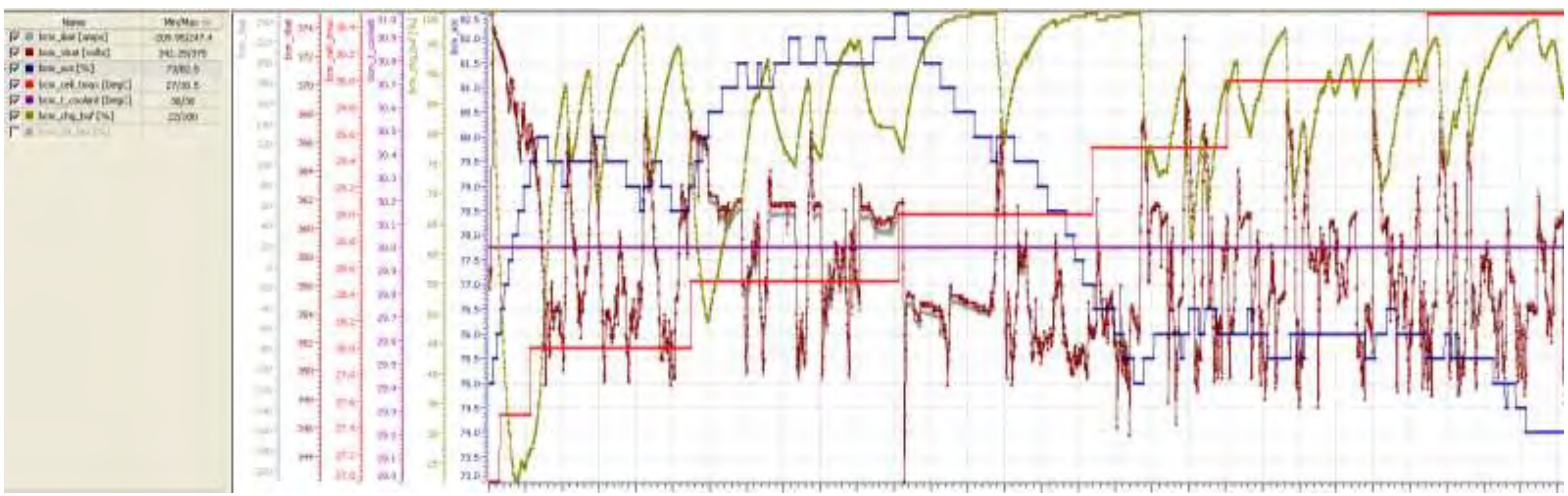
Performance with and without liquid cooling

	No Liquid Cooling				With Liquid Cooling			
	CHARGE		DISCHARGE		CHARGE		DISCHARGE	
Duration	CONT	10-sec	CONT	10-sec	CONT	10-sec	CONT	10-sec
Test Pack Power (kW)	-22	-67	21	61	-22	-113	61	184
Pack Vmax	389	389	389	389	389	389	389	389
Pack Vnom	350	350	350	350	350	350	350	350
Pack Vmin	270	270	270	270	270	270	270	270
Min Pack Energy (kW-Hr)	19.8				19.8			
Test Current (A)	-60	-180	60	180	-60	-300	180	600
Test Temperature (DegC)	25	25	25	25	25	25	25	25
Test SOC (%)	50	50	50	50	50	50	50	50

Pack Characteristics

Preliminary Simulation Results

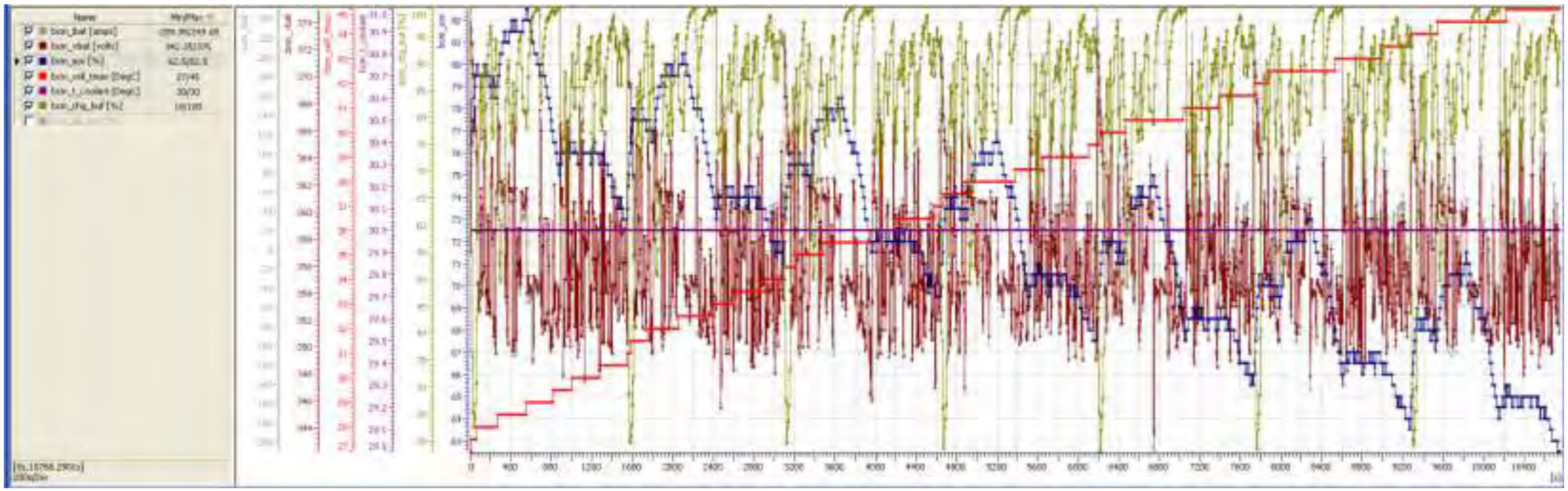
- Duty cycle requirements taken from Gen1 pack during testing used to simulate Gen2 battery performance for various scenarios
- Aberdeen duty cycle
  - Over 25 minutes of battery usage, with no cooling
  - Pack met all performance requirements
  - Battery temperature rise less than 4 deg C



Pack Characteristics

Preliminary Simulation Results

- Repeating Aberdeen cycle for 3 hours still shows pack meeting performance and not exceeding cell temperature limits (without applying cooling)



Current Status

Running Gen 1 profiles from testing on battery cycler to compare performance with Gen 2 pack

Pack to be delivered to DRS in Jun 2011

Conclusion

- HE vehicles are becoming commonplace in commercial market; anticipate the same for Military Markets in years to come
- The “Generation 1” A123/DRS/TARDEC pack worked very well in bench and vehicle testing
- An upgraded prismatic pack would enhance the overall performance at a reasonable cost
- Preliminary simulation and testing shows increased performance over “Generation 1 pack”
- In-Vehicle testing will begin this summer

Special Thanks

A123 SYSTEMS

DRS TECHNOLOGIES
A Finmeccanica Company

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JP-8 Compatible Fuel Cell Gensets at Lockheed Martin

2011 Joint Service Power Expo

Myrtle Beach, SC

4 May 2011

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Motivation – Reduce Genset Fuel Usage

- ***Army: 357 million gallons of fuel per year just for gensets.***
  - ***Largest single consumer of fuel – and very distributed***
- ***Tens to hundreds of dollars per gallon to get to soldiers in field***
- ***Major cost in lives***
- ***Our JP-8 compatible solid oxide fuel cell (SOFC) gensets can reduce fuel usage***

Fuel convoys are vulnerable to attack.

AP – 1 October 2010 - ISLAMABAD, Pakistan –Assailants in Pakistan launched two separate attacks Friday on vehicles carrying fuel for NATO and American forces in Afghanistan, highlighting the vulnerability of the U.S.-led mission…

AP – 25 February 2011 - ISLAMABAD, Pakistan – Militants in northwestern Pakistan blew up at least 11 tankers carrying fuel for NATO troops in neighboring Afghanistan and shot dead four people, police said.

"Free us from the tether of fuel"

Marine Corps Maj. Gen. Mattis
(now Commander, U.S. Central Command)

"By reducing the need for [petroleum] at our outlying bases, we can decrease the frequency of logistics convoys on the road, thereby reducing the danger to our marines, soldiers, and sailors."
Marine Corps Maj. Gen. Richard Zilmer, former top U.S. commander in western Iraq

Why Solid Oxide Fuel Cells for Gensets?

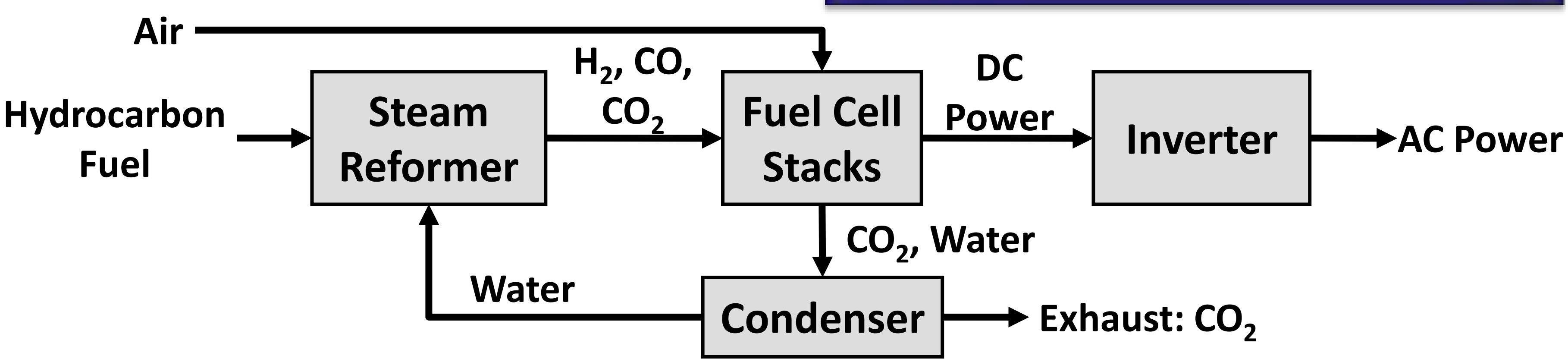
Why SOFC Technology?

- Combined with a fuel reformer, solid oxide fuel cells can be much more fuel efficient than current gensets
- Quiet - no large mechanical moving parts
- Less Pollution – No Combustion

But…

- Must be compatible with JP-8 per DoD "One Fuel Forward" policy
- Problem – sulfur contained in these fuels poison reformer and fuel cell catalysts

Basic reformer / fuel cell system diagram



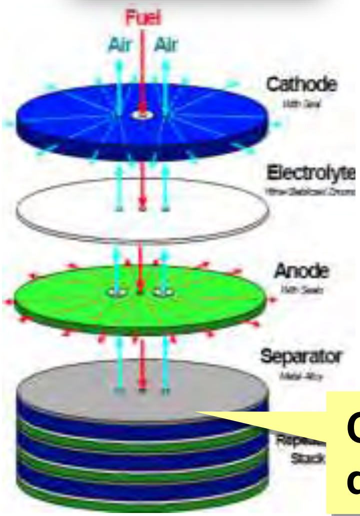
Why TMI's SOFC Technology?

- <u>Sulfur tolerant</u> – Unlike other fuel cells, ours operates directly on JP-8 and other sulfur-containing fuels.
  - Recently completed 1,000-hr test on standard DoD-supplied JP-8
  - No desulfurization complexity or inefficiencies
- <u>Fuel flexibility</u>: Uses JP-8 as well as other fuels such as soybean and other vegetable oils, natural gas, syngas, propane, Jet-A, diesel, biodiesel, etc.
- Simple cell design enables <u>low manufacturing costs</u>
- Quiet and clean – can operate indoors

LM Partner: Technology Management Inc.

- Small business
- LM working with TMI since 1993

2" diameter



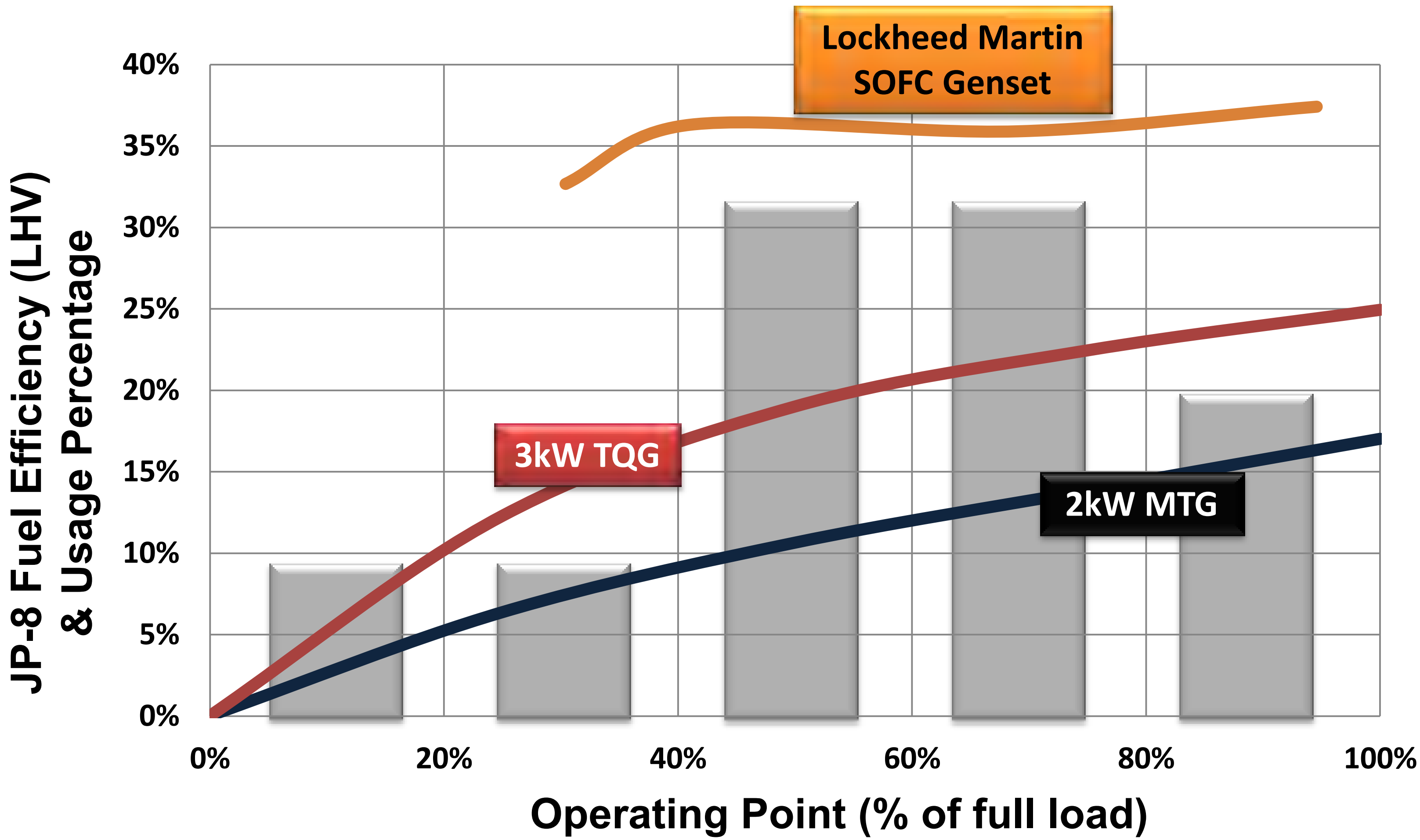
Core TMI stack technology designed for manufacturability

US Army BGEN Thomas Cole

Lab prototype operating on JP-8, Jet-A and diesel

Our SOFC technology uniquely operates efficiently on standard JP-8 fuel.

SOFC Genset Efficiency vs. Conventional Gensets



Projected usage of TQGs as function of load. *Source: ORNL: "Advanced Power Generation Systems for the 21st Century"*

LM's SOFC Gensets are *double* the efficiency of current DoD Gensets

LM/TMI SOFC Genset Features

Feature	LM SOFC System
Fuel Efficiency	Up to twice as fuel efficient on JP-8 as conventional TQG
Fuel Flexibility	Core technology has been demonstrated with wide range of liquid and gaseous fuels, including JP-8, Jet-A, diesel, ammonia, natural gas, propane, soybean oil, jatropha oil, alcohols, syngas
Modularity	Core power electronics enable synchronization with external 60Hz source
Renewables Integration	Internal architecture enables simple addition of external renewable sources, such as solar panels, to further reduce fuel consumption
Lower Acoustic Signature	No large internal combustion engine noise. Only small, readily isolatable air blowers
Less Polluting	Less CO_2 per unit energy. Non-combustion process when operating; no NO_x, particulates

Recent SOFC System Accomplishments

- **System Readiness**
  - 1000-hour continuous test of JP-8 SOFC genset completed
    - Including transporting the operating system 42 miles (Cleveland to Akron)
  - Completed shock & vibration testing of integrated stacks and reformer
  - Conducted initial environmental testing for arid and humid environments
- **Incorporated design improvements**
  - Ruggedization, reliability, maintainability
  - Operability - One-button stand-alone start up process
  - Embedded controller
  - Developed flex-fuel and renewables interface
- **Achieving/exceeding fuel efficiency objectives**
  - Significant efficiency improvement measured against conventional gensets
  - Validated over a wide range of loads
- **Development contracts with the Army CERDEC and Ohio Third Frontier**

Ruggedizing our proven JP-8 compatible fuel cell technology

System Testing and Ruggedization

Shock and Vibration

Developed shock & vibe mounting approach and performed testing of Hot Subassembly and major BOP components.

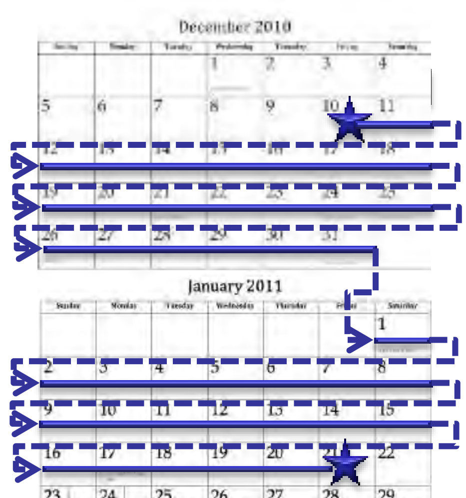
Vibration: MIL-STD-810G 514.6C-2, Random Vibration – Two-Wheeled Trailer

Shock: MIL-STD-810G 516.6-8, Functional Test for Ground Equipment

Endurance Testing

1000-hour test recently completed

Running with standard JP-8 fuel provided by AFRL Wright-Patterson



Temperature & Humidity

Initial temperature & humidity testing of system

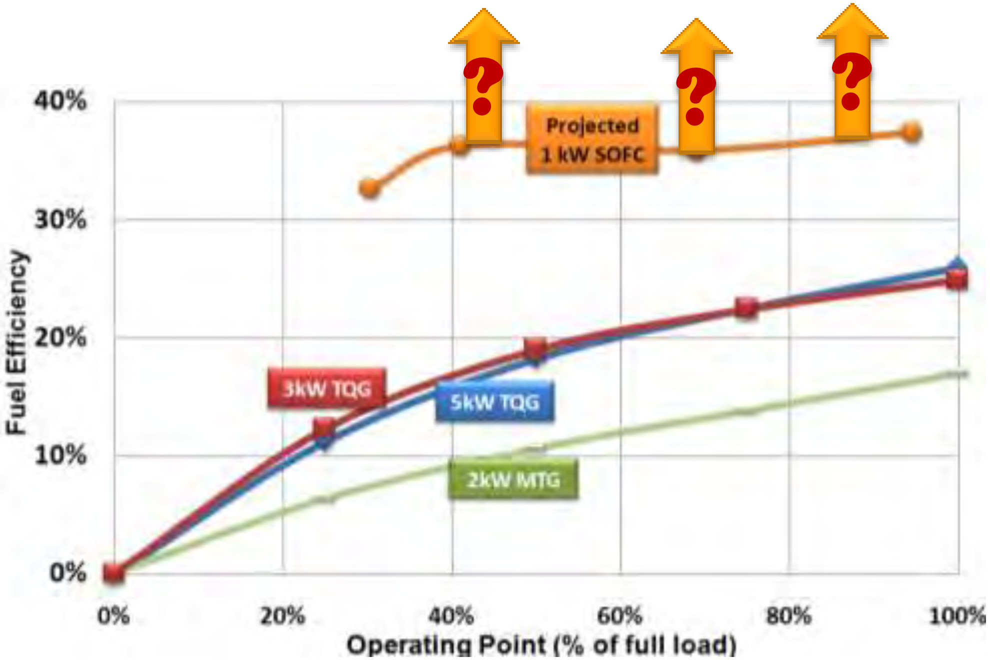
- Temperature 110°F; low RH (~20%)
- Temperature 95°F; high RH (~90%)
- Day / night cycling
- Focus on initial quick assessment of COTS components in system

Moving the TRL forward

Energy Node Concept

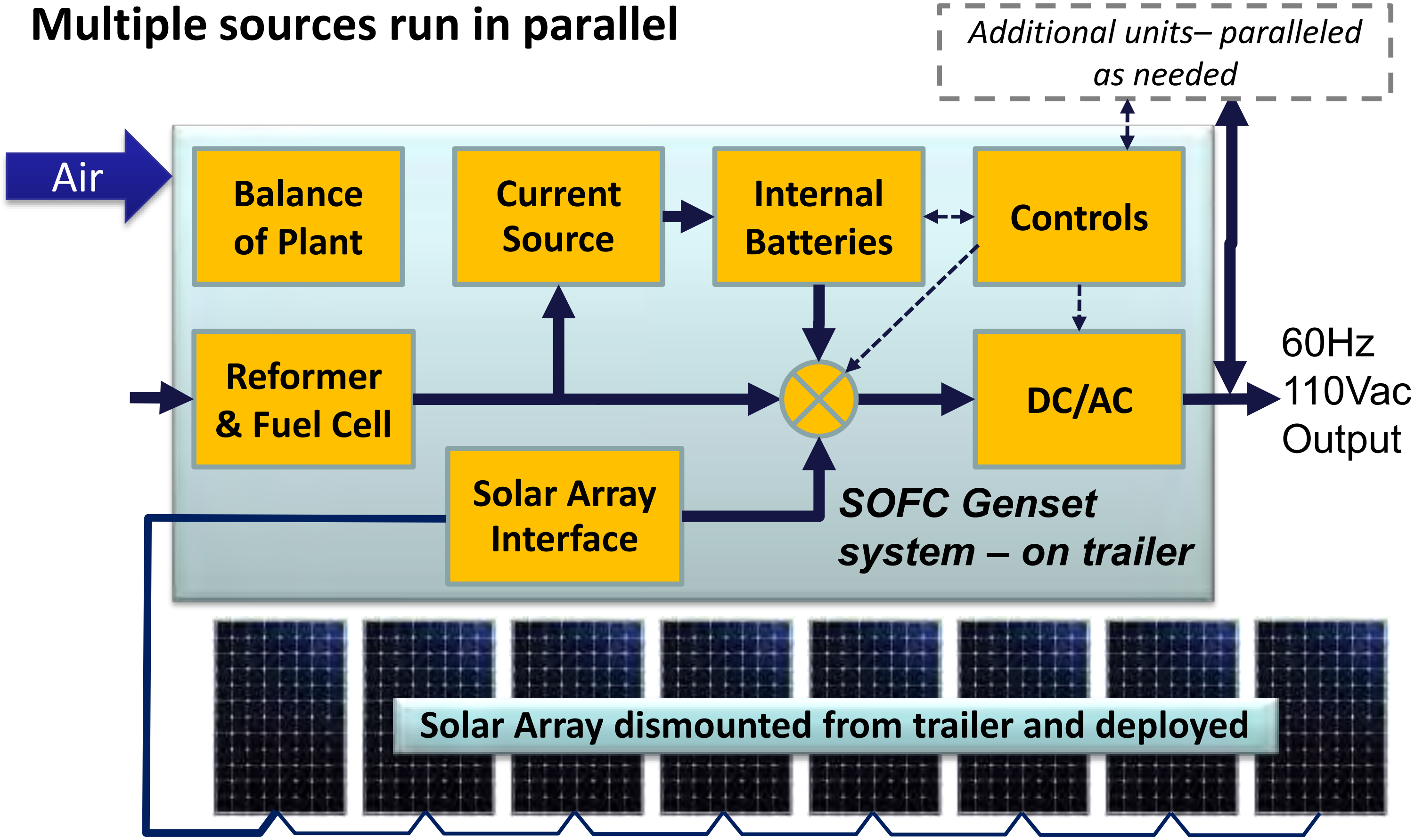
Our SOFC Genset internal design enables further fuel efficiency enhancements:

- Simple additions enable ***insertion of renewable sources*** to reduce fuel usage – leverages existing inverter and controls
- Multiple SOFC ***gensets designed to be directly paralleled***
- Core technology is ***flex-fuel capable*** – just need to provide simple interface and controls in balance-of-plant



Adding Renewable Sources

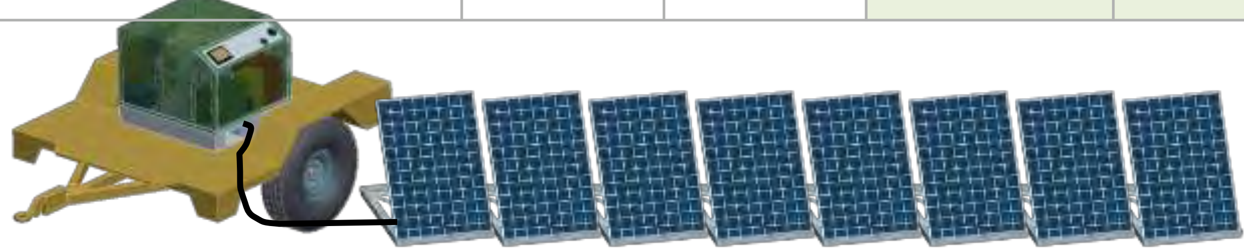
- Adjustments to internal design allows generic DC sources to displace fuel cell-generated power as required
- Controls select which current sources to use which maximizes efficiency of fuel cell system
- Multiple sources run in parallel



Energy Node – Even Greater Fuel Savings

- Significant fuel savings, even if solar is not available
- Addition of simple solar panels further increases fuel savings
- No need for extra components to convert solar power, interface to grid, energy storage, etc.

	3kW TQG		3kW SOFC Genset	
Operating Load	50%	100%	50%	100%
Fuel usage per day	5.1 gpd	7.9 gpd	2.9 gpd	5.8 gpd
Savings (just fuel cell)	n/a	n/a	43%	27%
With solar panels *	5.1 gpd	7.9 gpd	1.3 gpd	3.9 gpd
Fuel savings with solar	n/a	n/a	74%	51%



Summary

- Definitive need to substantially drive down fuel usage in theaters of operation
  - Savings in both lives and dollars
- Lockheed Martin's proven SOFC JP-8 genset will help achieve this goal by using 50% less fuel than currently deployed gensets
- The Lockheed Martin/TMI genset is inherently designed to be compatible with "plug-n-play" energy solutions such as micro-grid and renewable power sources
  - This compatibility will dramatically increase energy efficiencies while driving down costs
- Fuel flexibility provides the additional benefit of using indigenous fuels on an as needed basis

As a "stand alone" system or as part of a networked solution, the Lockheed Martin SOFC genset will significantly remove tankers from convoy supply lines

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Reducing Warfighter Load by Increasing Energy Density

SFC ENERGY

May 4, 2011

Phil Hassell
Sales and Business Development Manager
Defense & Government
SFC Energy, Inc.

Outline

- Problem Statement
- Soldier Portable Energy Sources
- Energy Density
- Sample Soldier Load Study
- SFC Overview
- Summary

Problem Statement

- Warfighter load ranges from 80-180 lbs based on mission and squad role
  - Increased Fatigue
  - Decreased Effectiveness
  - Decreased Mission Duration
- 30-40% of that load is dedicated to energy

The Warfighter needs a lighter power solution

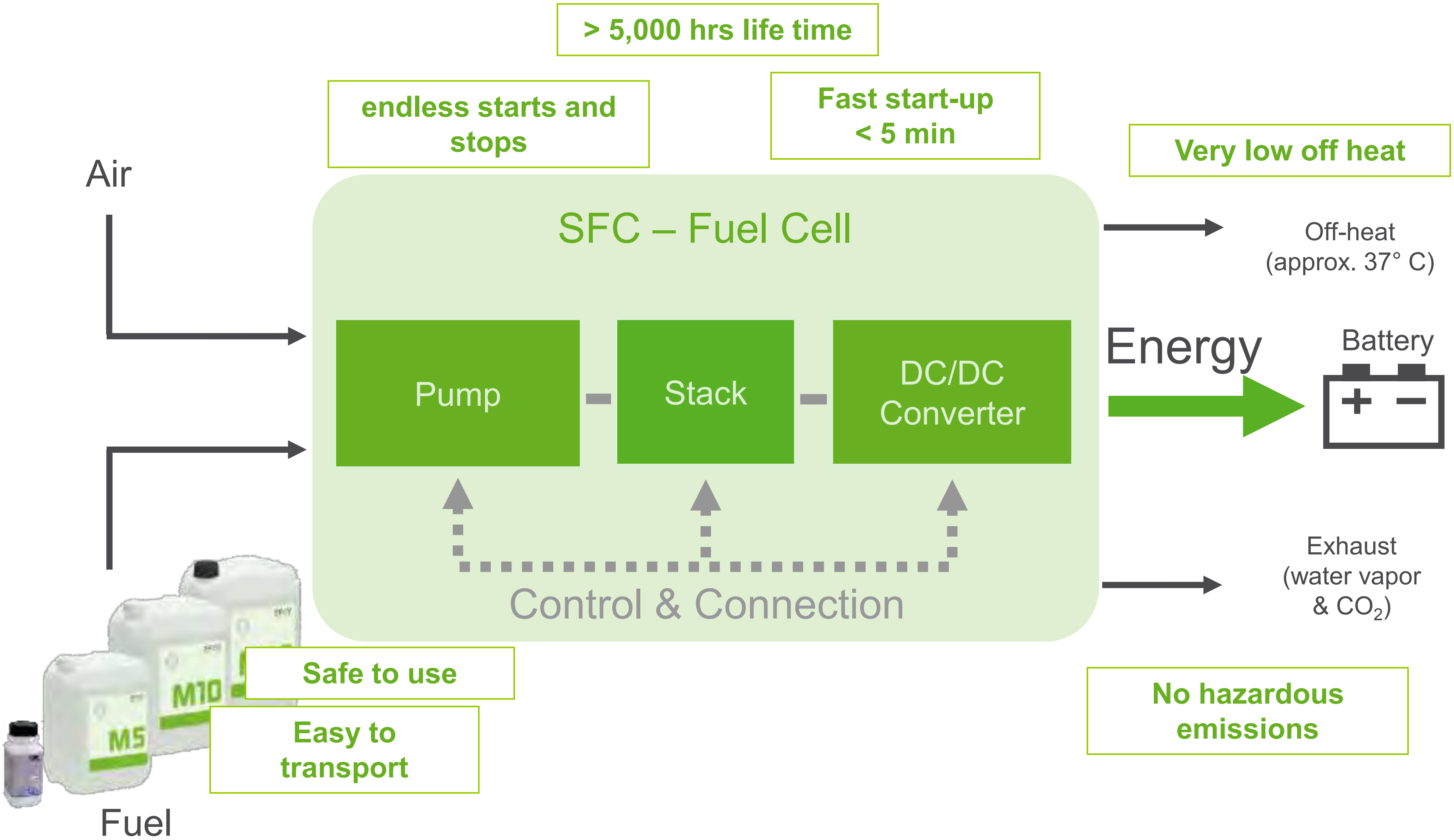
Soldier Portable Energy Sources - Requirements

- Lightweight and low volume
- Capable of 500-700 Wh/day
- Minimal operator management
- Low signature (noise, heat, and visibility)
- No hazardous emissions

Soldier Portable Energy Sources

- Direct Methanol Fuel Cells (DMFC)
- Batteries

Soldier Portable Power Sources – DMFC Technology



Soldier Portable Energy Sources - DMFC

- JENNY 600S – portable fuel cell
  - Minimal operator management – single fuel cartridge lasts 16 hours
  - Low heat and noise signature
  - Operates without emissions
  - Ruggedized for military field operation

- SFC Power Manager – portable energy management
  - Simple to use
  - Manages sources and loads without user input
  - Enables energy harvesting from different sources
  - Creates modular power network

SFC DMFC and Power Management systems offer immediate COTS solution!

Soldier Portable Energy Sources – DMFC (cont'd)

System	Weight (lbs (kg))	Size (in (mm))	Energy (Wh)
 JENNY 600S	3.74 (1.7)	7.2 x 2.9 x 9.9 (184 x 74 x 252)	600/day
 M0.35 Cartridge	.82 (0.371)	6.5 x 2.4 x 2.4 (165 x 60 x 60)	400
 Power Manager 3G	1.05 (0.48)	5.2 x 3.4 x 2.4 (131 x 87 x 61)	

Soldier Portable Energy Sources – DMFC (cont'd)

batteries
30 Wh/kg

⏻ **270 kg**

11 kWh energy !

Methanol: 35 times higher energy density than batteries

Methanol combines superior energy density with easy handling, shipping and low cost.

Methanol (M10)
1,1 kWh/kg

⏻ **8 kg, 10 l**

Energy dense fuel leads to lower warfighter loads

Soldier Portable Energy Sources - Batteries

Battery Type	Voltage (V)	Capacity (Ah)	Size (in (mm))	Weight (lbs(kg))	Energy (Wh)
 BB-521	9.6	1.2	2.8 x 3.0 x 1.5 (71 x 75 x 38)	0.8 (0.35)	11.5
 BA-5590	15.0	15.0	5.0 x 4.4 x 2.4 (126 x 111 x 62)	2.2 (1)	225.0
 BB-2590	14.4	12.4	4.4 x 2.45 x 5 (112 x 62 x 127)	3.1 (1.4)	178.6
 AA	1.5	1.5	0.55D x 2 (14D x 50)	.05 (0.024)	2.3
 CR123	3.0	1.2	0.65D x 1.3 (16.5D x 34)	.04 (0.017)	3.7

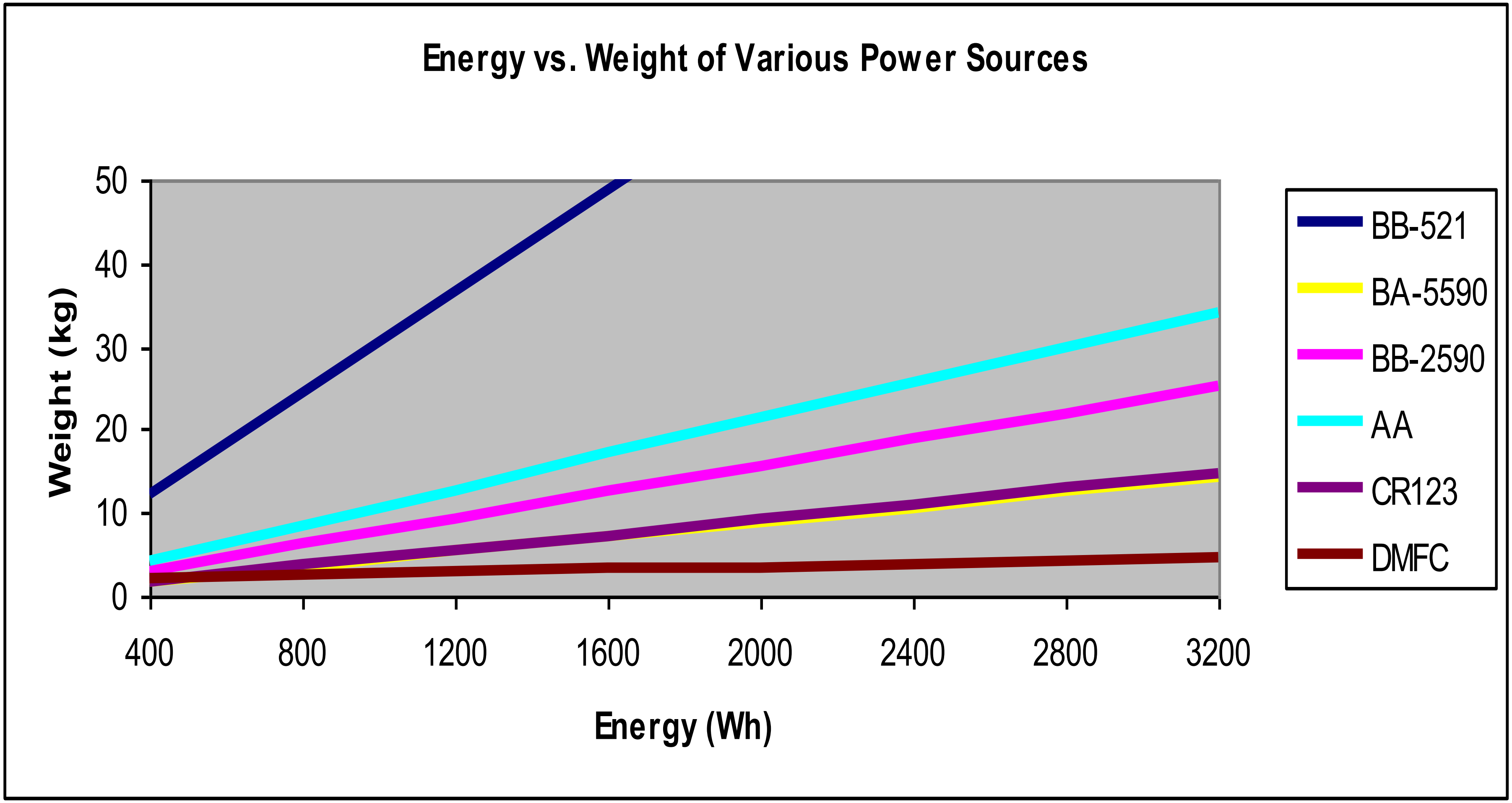
High energy density – 1,400+ Wh/kg

That delivers **10 kWh** electricity

	Methanol	Hydrogen	Lithium Batteries	Lead-acid batteries
				
Weight:	8 kg	85 kg	110 kg	270 kg

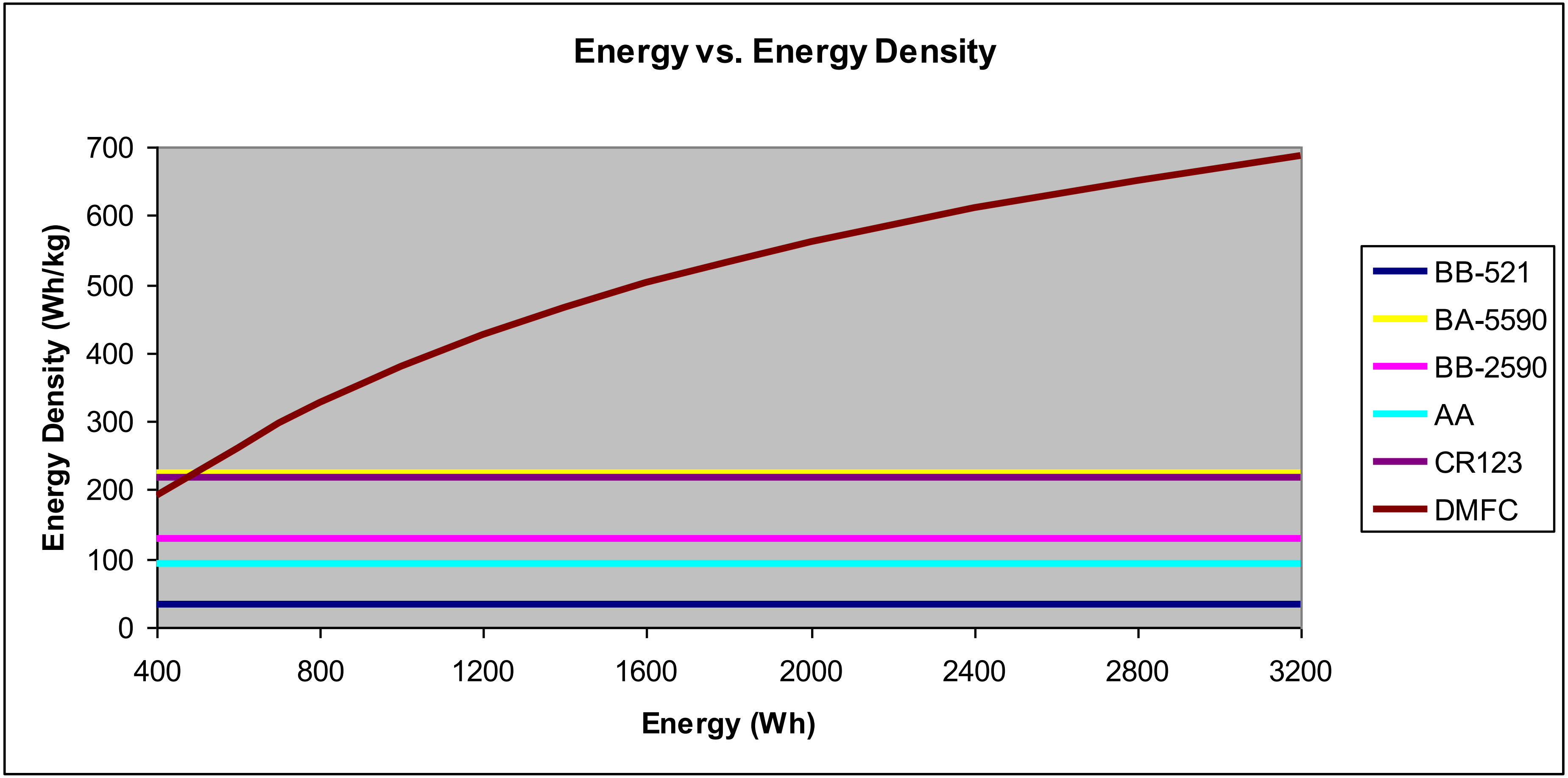
Methanol combines outstanding energy density with easy handling and low costs.

Energy Density



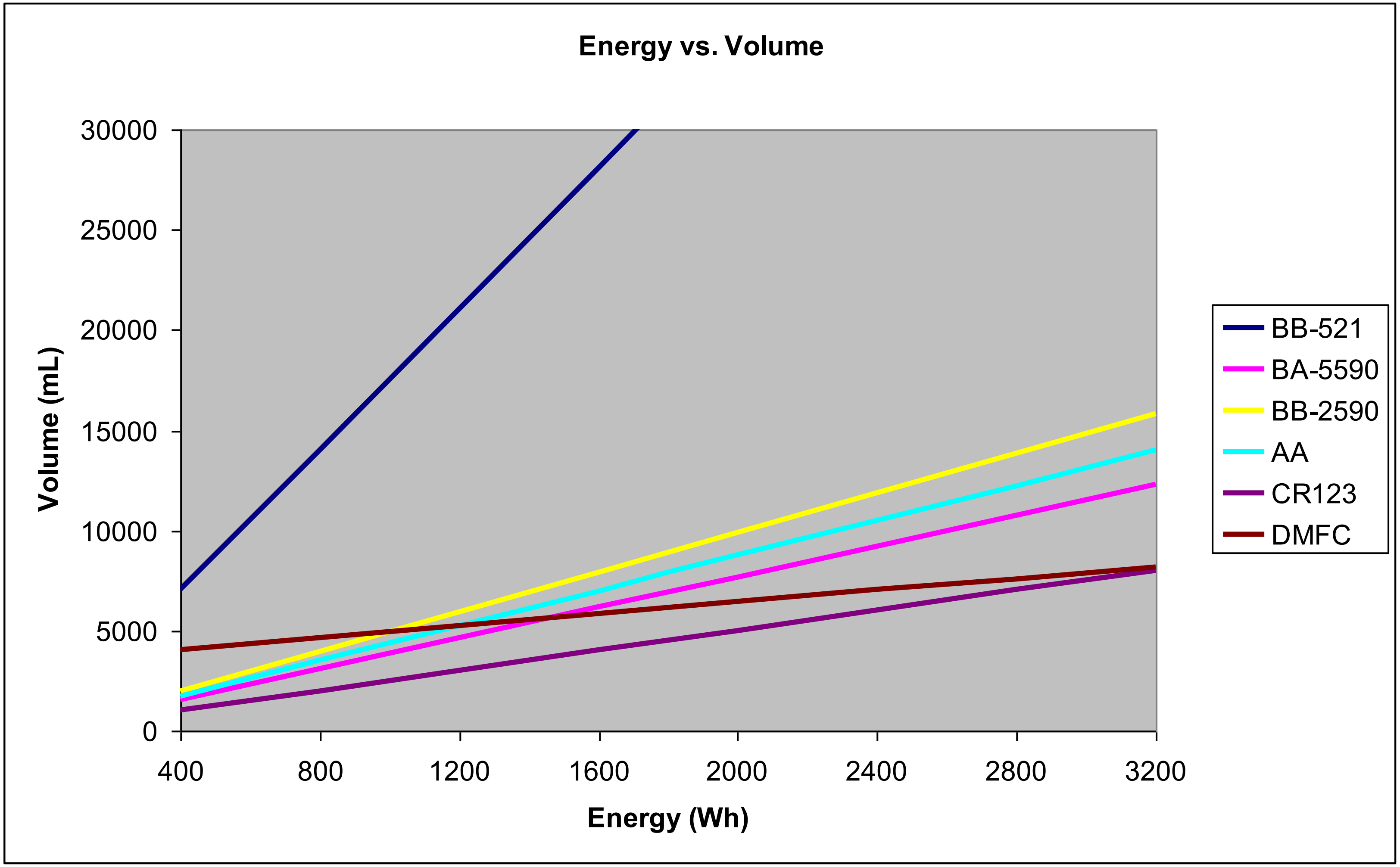
DMFC offers significant weight reduction vs. batteries

Energy Density – Energy vs. Weight



As energy need increases, DMFC energy density increases

Energy Density – Energy vs. Volume



Energy Density - Logistics Load

- Pallet Size – 104 x 84 x 96 in, 10000 lbs
- Load limited by weight, not volume

Battery Type	Weight	Energy (Wh)	Quantity per Pallet	Energy per Pallet	Pallets Needed for Same Energy as 1 Pallet of M28
BB-521	0.35	11.52	12,928	148,933	42.95
BA-5590	1	225	4,525	1,018,100	6.28
BB-2590	1.4	178.56	3,232	577,117	11.08
AA	0.024	2.25	188,537	424,208	15.08
CR123	0.017	3.7	266,170	984,828	6.50
M0.35	0.371	400	12,196	4,878,584	1.31
M28	22	31100	206	6,396,545	

Logisitics load can be reduced significantly with DMFC

Sample Soldier Load Study

- 3 Load Configurations
  - Using batteries only
  - Using only DMFC
  - Using DMFC as battery charger
- Based on total energy use of approximately 600 Wh/day

Sample Soldier Load Study – Batteries Only

Batteries	Quantity per Day	Energy (Wh per Battery)	Energy (Wh) per day
BB-521	3	11.52	34.56
BB-2590	3	178.56	535.68
AA	8	2.25	18
CR-123	4	3.7	14.8
		Total Energy (Wh) per day	603.04

Sample Soldier Load Study – DMFC Only

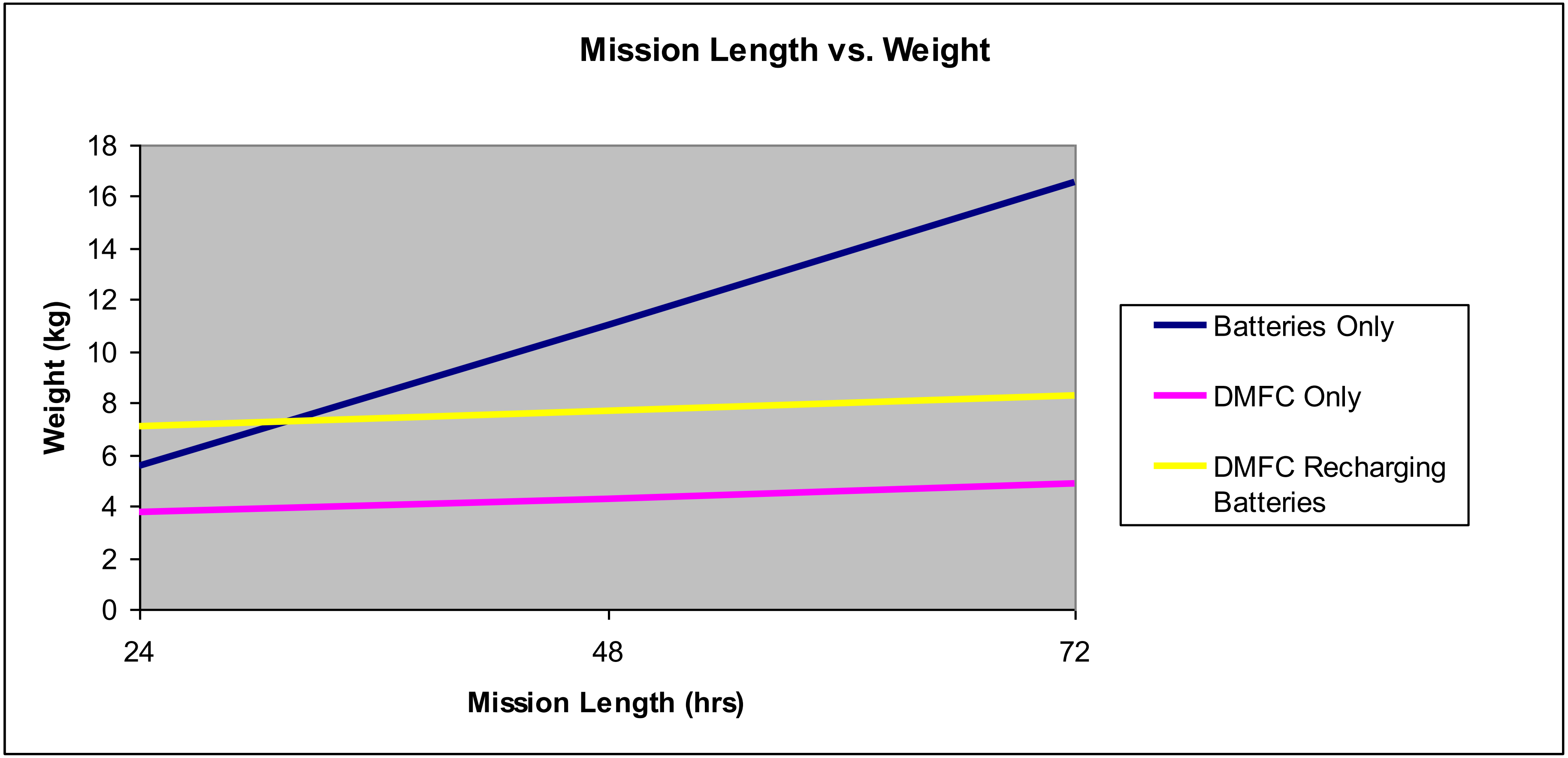
- All systems powered directly from DFMC
- Power distributed via Power Manager 3G

Soldier Equipment

Soldier Load Study – DMFC as Battery Charger

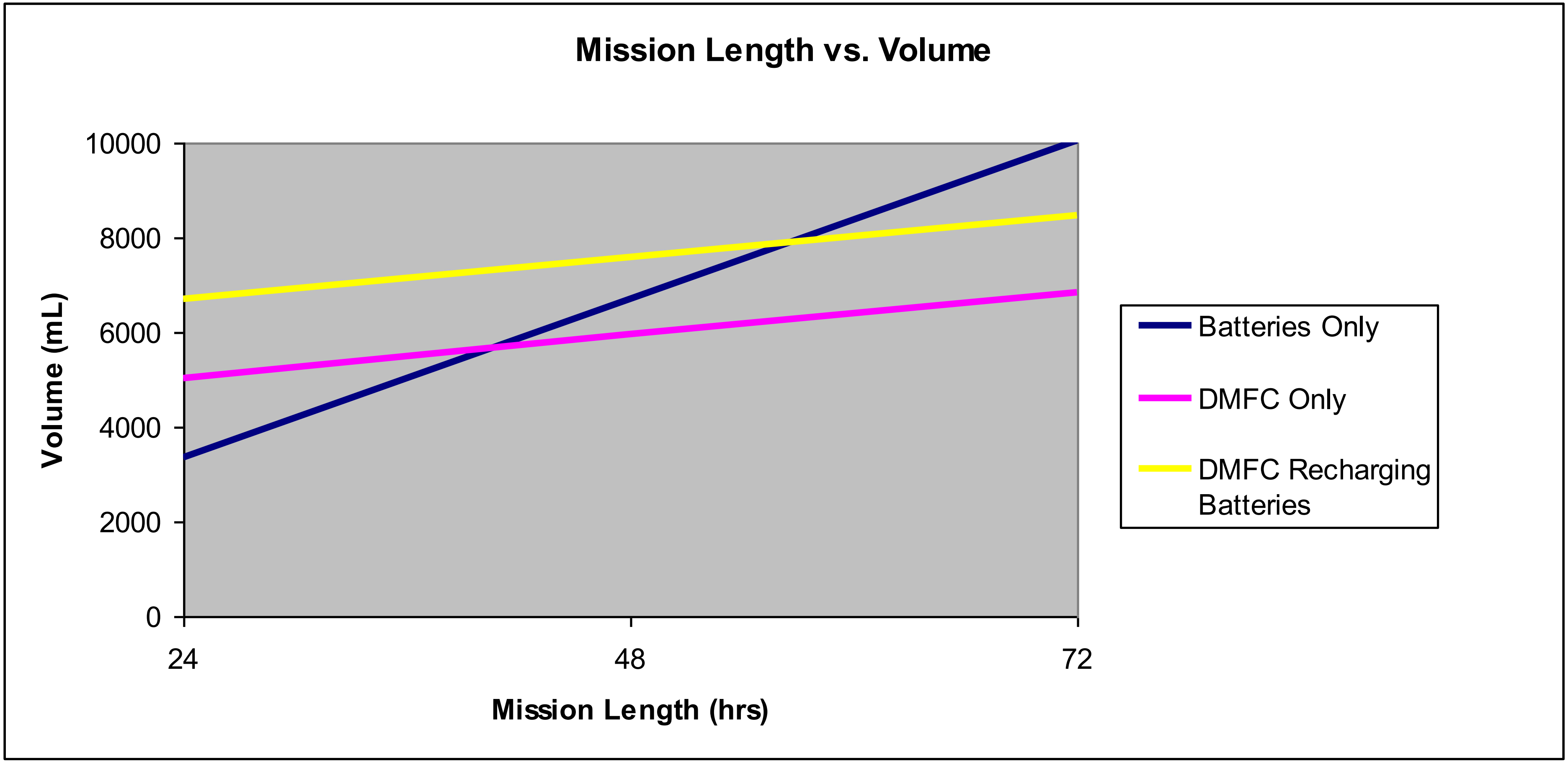
- Systems powered by battery
- Batteries recharged by DMFC
- Spare batteries for recharging included in weight calculation (2 x BB-521, 2 x BB-2590, 8 x AA, 4 x CR123)

Soldier Load Study – Mission Length vs. Weight



DMFC quickly becomes a weight saver

Soldier Load Study – Mission Length vs. Volume



DMFC is comparable and gradually better than batteries

Soldier Load Study - Summary

Configuration	Weight (kg)	Weight Savings (kg)	Weight Savings (%)	Volume (L)	Volume Savings (L)	Volume Savings (%)
Batteries Only						
24 hrs	5.51			3.35		
48 hrs	11.02			6.69		
72 hrs	16.53			10.04		
DMFC Only						
24 hrs	3.74	1.77	32%	5.04	-1.69	-50%
48 hrs	4.30	6.72	61%	5.93	0.76	11%
72 hrs	4.86	11.67	71%	6.83	3.21	32%
DMFC Recharging Batteries						
24 hrs	7.12	-1.61	-29%	6.69	-3.34	-100%
48 hrs	7.68	3.34	30%	7.58	-0.89	-13%
72 hrs	8.23	8.30	50%	8.48	1.57	16%

DMFC can save 50-70% weight on a 72 hour mission

SFC Overview

Facts and figures

- Founded in 2000
- Sole company developing, producing and selling commercially available DMFC products
- Location:
  - Brunnthal, Germany (HQ)
  - Washington D.C., USA
- Number of employees: 95
- IPO in 2007

Products

- Energy solutions and power management
- DMFC fuel cell systems
- Fuel cartridges

Winner of DoD Wearable Power Prize Competition 2008

System Requirements

- Total system weight: ≤ 4 kg (including all equipment to operate the system)
- Time Duration : 96 hours (92 hours bench test, 4 hours field test)
- Voltage Out: 14 V DC and 28 V DC
- Average Power: 20 Watts
- Peak Power: 200 Watts -multiple increments up to 5 minutes

Winning Criteria

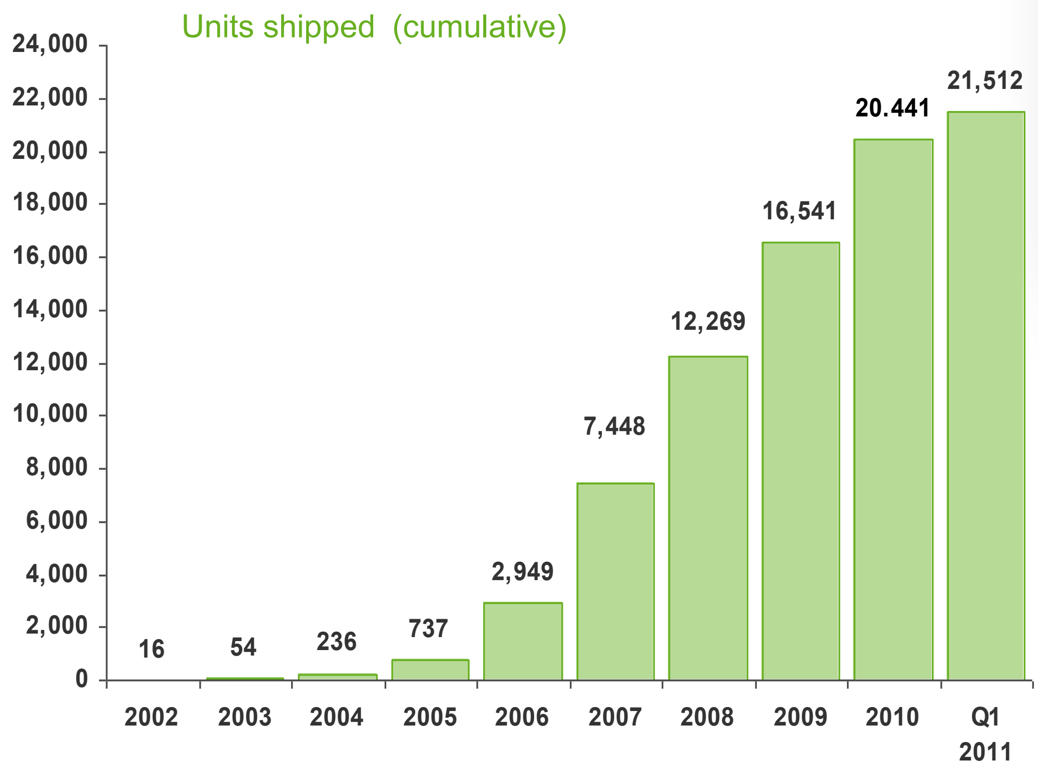
- 1. Weight
- 2. Protrusion (in case weights are identical)

Winner

- 1st place: M-25 (SFC with DuPont)
- 3rd place: JENNY 600S (SFC with CCLLC)

Market Traction

- As of today, more than 20,000 fuel cell systems shipped
- > 8 million operating hours in end user environments
- Fully functional fuel infrastructure established in core markets



SFC Overview - Market Segments

Defense

Weight Saving and Non-Detectability for:
Portable Power

Reliability and Non-Detectability of On-Board Power for:
Tactical Vehicles

Remote Industry

Dependability and Low Maintenance Cost for:
Traffic Technologies, Security, Environmental Monitoring

Mobility - APU

Reliability of On-Board Power and Reduction of Fleet Operating Costs for:

Special Purpose Vehicles

E-Mobility

Combined Heat and Power Source for:

Increased performance and user acceptance of battery vehicles

Leisure

Comfortonomy for:
Motor Homes, Cabins and Boats

Advantages of SFC Fuel Cells

Sustainability

Methanol can not escape from a DMFC fuel cell system and methanol is easily biodegradable.

SFC fuel cells reduce logistic efforts

All SFC fuel cells can be recycled by SFC

Methanol is made of waste or waste-products of oil exploration

SFC fuel cells virtually fulfil zero emission standards

Low environmental impact allows operation in protected areas

Maximum 76 grams CO_2 per hour

SFC Overview – Miltary and Government Users

Federal Bureau of Investigations

US AFSOC

US Army PEO Soldier, Natick Soldier Center, ATEC

German Armed Forces

Austria Armed Forces

NATO- & PfP States – Canada, Denmark, France, Finland, The Netherlands, Norway, South Africa, Sweden, Switzerland, Great Britain

Summary

SFC ENERGY

Advantage	Benefit
High Energy Density	50-70% Weight Reduction on 72-hour missions; at least 400% reduction in logistical load
COTS Technology	Reliable, Readily available solution can be deployed today
Minimal waste	Load decreases as more energy is used
Plug-and-play, self-regulating	Simple to use, minimal operator management
Modular energy system	Power can be sources from batteries, fuel cell, solar panel, AC, and vehicle power

DMFC offers a simple, reliable, readily available solution for reducing warfighter load

Contact Info

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Visit SFC Energy at Booth 420!

Thank you for your attention!

References

- CR123 datasheet - http://www1.duracell.com/oem/Pdf/new/Li123_US_OS.pdf
- AA datasheet - http://www1.duracell.com/oem/Pdf/new/MX1500_US_UL.pdf
- BA-5590 datasheet - http://www.batterystore.com/Saft/SaftPDF/BA5590.pdf
- BB-2590 datasheet - http://www.bren-tronics.com/pdf/BB2590.pdf
- BB-521 datasheet - http://www.maifl.com/pdfs/BB521.pdf
- Soldier Load data courtesy of Natick Soldier Systems Center

combined **strength**

Solid Oxide Fuel Cells to Reduce the Logistics Burden

Saving time, saving money, saving lives while expanding the flexibility and capability of small units

Jon Rice
Ultra Electronics – AMI
5500 South State St
Ann Arbor, MI 48108

Outline

- AMI Introduction
- 300 Watt APU
  - Limited User Test & Feedback
- Right Sizing Power Solutions
- Real World Costs

AMI

ANN ARBOR, MICHIGAN

- Portable Solid Oxide Fuel Cell Systems
  - 50W to 500W continuous power generation
- Acquired by Ultra Electronics in January 2011
- Located in Ann Arbor, Michigan USA
  - Founded in 2001
  - > 65 Full-Time employees

LEADING THE PORTABLE POWER REVOLUTION

Ultra ELECTRONICS

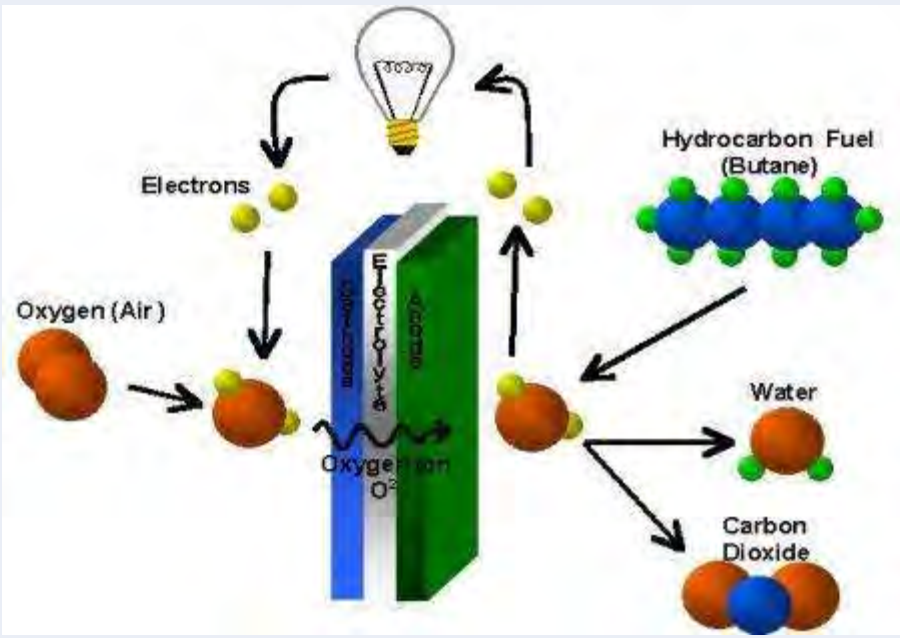
AMI
MANUFACTURING CAPABILITY

- Facilities
  - 48,000 ft^2
  - Multi-purpose (Research / R&D / Production)
- Building Volume Production Capacity
  - Tube Production
  - Cell Fabrication
  - Stack Production
  - System Assembly
  - System Validation

POWDER TO POWER UNDER ONE ROOF

Fuel Cell Technology

Solid Oxide Fuel Cell (SOFC)



AMI SOFC Technology

Rugged and High Performance

Solid Oxide Fuel Cells

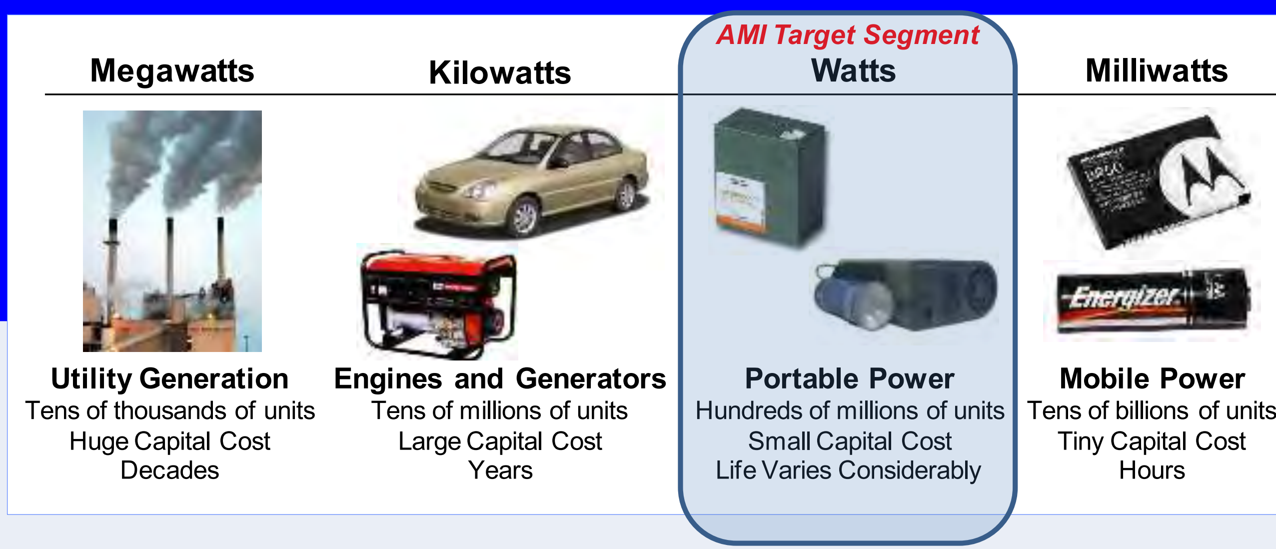
- Ceramic Fuel Cells
  - Inexpensive raw materials
- Tubular SOFC Architecture
  - Thermal shock – rapid start
  - Mechanical shock - rugged
- High Temperature, 600-800°C
  - ★ Direct hydrocarbon fuels

Ultra ELECTRONICS

Power and Energy Segmentation

AMI TARGETS 50 TO 500 WATT APPLICATIONS

- Increasing power demands of portable devices
- Existing solutions are insufficient
  - Too big for batteries: not replenished by fuel; size and runtime constraints
  - Too small for engines: many moving parts; bulky, heavy, noisy, dirty
- Low capital costs make purchasing accessible



AMI

FUEL CELLS IN OPERATION

- AMI fuel cells have been deployed in the most demanding environments for a variety of applications.

Cobra Gold
Thailand

MEDRETE
Dominican Republic

•RUGGED, LIGHTWEIGHT, RELIABLE
•GLOBALLY AVAILABLE FUELS

AMI
PORTABLE SOFC APPLICATIONS

- Broad End Markets
  - Man portable power
  - ISR
  - Unmanned systems
- AMI Fuel Cells deliver energy wherever and whenever it's needed most.




PROPANE, POWER, PRICE ADVANTAGE

Energy & Availability = Capability

Energy

BA5590 Military Battery

~170 Watt-hour
~$90

1,000 Watt-hour
$2.47

Fuel Availability

Afghanistan

Iraq

Outline

- AMI Introduction
- 300 Watt APU
  - Limited User Test & Feedback
- Right Sizing Power Solutions
- Real World Costs

300 Watt APU

- Volume
  - 15.75” by 8” by 14”
  - 29 L (34 L with fuel sub)
- Mass
  - 11.6 KG
- Performance
  - 300W at 28.8 Volts
  - 200-300 On/Off Cycles
- Fuel Consumption
  - 0.12 kg/hr

Limited User Testing, Fort Riley Kansas

300 Watt Charger

- 2 days of missions
  - 3 testing lane
  - Multiple mission scenarios
- Immediate feedback from Soldier on system effectiveness

Limited User Testing, User Feedback

300 Watt Charger

- User Feedback
  - Too big and heavy for Tier 1 operation – make it smaller
  - Easy to use – operation was simple
  - User interface was too hard to read in low light
  - Remove the battery charger and make it a stand along power supply
  - They already buy propane from local sources when they set up in foreign locations
    - User wanted to be able to use local propane sources
- AMI's Response
  - Eliminated battery charger reducing total weight to <25lbs
  - Added display backlight for ease of use
  - Added a fuel line for use with COTS propane tanks

300 Watt APU

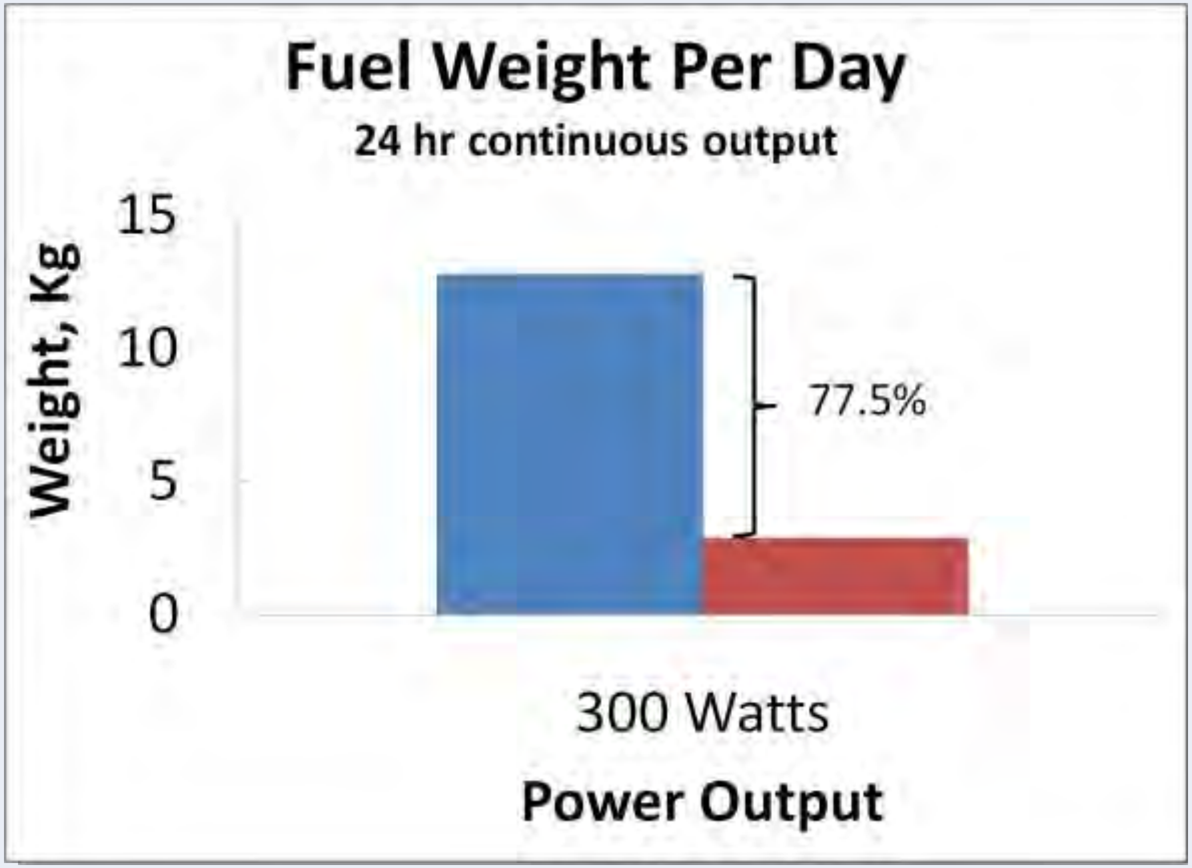
- System scheduled for shipment to Afghanistan in July 2011

Outline

- AMI Introduction
- 300 Watt APU
  - Limited User Test & Feedback
- Right Sizing Power Solutions
- Real World Costs

Right Sizing Power Solutions

Sample Scenarios



77.5% reduction in fuel resupply to maintain operations

Real World Examples

Right sizing power solutions

- Cobra Gold 2009
    - 3 kw TQG
    - Charging an iPod
- MEDRETE – Dom Rep
    - 5 gallons of JP-8 to run a 3kW generator for a day
    - Powering a single laptop
    - Flown in on a CH-53E
        - $20,000 / flight hour

- **Matching the demand to the supply is critical in maximizing efficiency and lowering operating cost**

Real World Costs

- “The casualty factor for fuel resupply in Afghanistan is .042 …… for every fuel-related resupply convoy or one casualty for every 24 fuel resupply convoys in Afghanistan. (AEPI Report 2009, Sustain the Mission Project: Casualty Factors for Fuel and Water Resupply Convoys)

- “Due to poor to non-existent roadway infrastructure, and the high risk of enemy activity, Wasa K’wah has not had a convoy ground resupply in nearly three years. “Tech. Sgt. Stacia Zachary

- “The GAO report said that in June 2008 alone, 6.2 million gallons of fuel went for air and ground operations, while 917,000 gallons went for base support activities including lighting, running computers, and heating or cooling.” (The Washington Post, December 2009)

Questions?

Smaller, Better, Greener

Saving time, saving money, saving lives

2011 Joint Service Power Expo

Regenerative Solar Power Solutions for Extended Mission Endurance

John Hart
ABSL Power Solutions Inc.
John.hart@abdg.com
617-319-1664

An EnerSys Company

EnerSys Power/Full Solutions

ABSL Power Solutions

People

142 employees

20 USA

122 UK

Capabilities

Thurso

Cell Design and Manufacture

Charging Design and Manufacturing

Battery Design and Manufacturing

Cell, Battery and Charger testing

Capabilities

Culham

Space Battery Design and Manufacturing

Space Battery Sales

Power Battery & Charger design

Power Sales

Capabilities

Longmont, Colorado

Space Battery Design and Assembly

Space Battery Sales

Military Power Sales

Capabilities

Herndon, Virginia

US Military Power Sales

Facilities

Manufacturing of Cells, Batteries & Chargers

Design and Engineering centres of Excellence

In house Qual & Test

Central location Sales team

ABSL POWER SOLUTIONS

An EnerSys Company

HCS Technologies

Founded in 1994, HCS Technologies is a Veteran-owned Service Disabled small business that designs, manufactures and sells intelligent controls and small-scale hybrid energy platforms for military, government, agricultural, and other uses.

Our products are well suited to remote and hazardous environments where conventional power generation, distribution, and management systems are impractical or costly.

We manufacture and sell the first built-in controller designed to monitor the inputs and outputs of a hybrid energy platform, a device we call "the Brain Box."

An EnerSys Company

Renewable Energy Systems

- **SPACES - Solar Portable Alternative Communications Energy System** consists of several foldable solar panels, a multitude of output and input cables and adapters, and a small box no bigger than the average game console.
  - power everything from AN/PRC-119F SINCGARS radios and combat operations centers

- **GREENS - Ground Renewable Expeditionary Energy System** harvests energy from many different sources, distributes the energy using an intelligent management system, and stores excess harvested energy

An EnerSys Company

Soldier Portable Power

Alternative Energy Objectives

- **Extending the power spectrum**
  - High efficiency /flexible / modular power conversion
  - PV /Wind /Geothermal Systems

- **Lightweight, Flexible, Cost Effective Solar Energy Photovoltaics**
  - Battery Recharging
  - Unattended Sensors
  - Surveillance Systems
  - Reduced Logistics
  - Modular integrated hardware systems to include solar source, energy storage and controls

An EnerSys Company

Man-Portable Solar Harvesting Kit

An EnerSys Company

EnerSys
Power/Full Solutions

Warner Energy Solar Recharger

Formerly Energy Masters

- Next generation 110W will weigh 5LB
- 22.5% efficient MILSPEC certified
- Currently in use for UAV / back-packable satellite / sensors

Deployed STAR-220 (Double STAR)

Double STAR: (pictured left)
176Wp and 220Wp Models
72" x 36" Fully Deployed
18.5" x 12" Folded
16lbs

Single STAR: (pictured right)
88Wp and 110Wp Models
72" x 18" Fully Deployed
12" x 18" Folded
8lbs

Wp = Watts Peak
5" Monocrystalline Cells
Anti-Glare Coating
Camouflage Available

STAR-110 (Single STAR)

Electrical Specifications:

STAR-110 Wp	STAR-220 Wp
Voc = 24.12 volts DC	Voc = 24.12 volts DC
Isc = 5.9 amps DC	Isc = 11.8 amps DC

Available Camouflage Patterns

HCS TECHNOLOGIES

ABSL POWER SOLUTIONS

An EnerSys Company

Smart Portable Charger (SPC)

- SPC Level 3 DC input multi-chemistry charger will charge any SMART battery (1-8 cell series)
- SPC charges any non-SMART battery (with appropriate SMART cable)
- Starts automatically when battery is connected
- Dual LED indicators for charger and battery status
- CAN bus interface via input connector – automated test and evaluation
- Information continuously transmitted over serial interface
- Future proof – ready for new batteries as developed
- Under evaluation by UK MoD as power supply to laptops and other small electronic equipment

- Input voltage 10.5V to 40V (shut off at 9.5V)
- Max. output 33.6V 180W (5.3A @ 33.6V / 6.0A @ 30.0V
- Max. input current 9A
- Charge terminated by battery or SMART cable.

An EnerSys Company

11Ah X590 Battery

Typical 2590 battery
with 18650 cells

Prototype X590 battery

- Weight: 1.4 kg
- 28.8 V: 7.2 Ah, 207 Wh
- Cycle Life: 240+
- Operational at -20°C to +55°C

• Weight:	1.5 kg
• 28.8V:	11 Ah, 316 Wh
• Cycle Life:	500+
•Operational at	-40C to +70C
1C discharge from	-20C to +55C

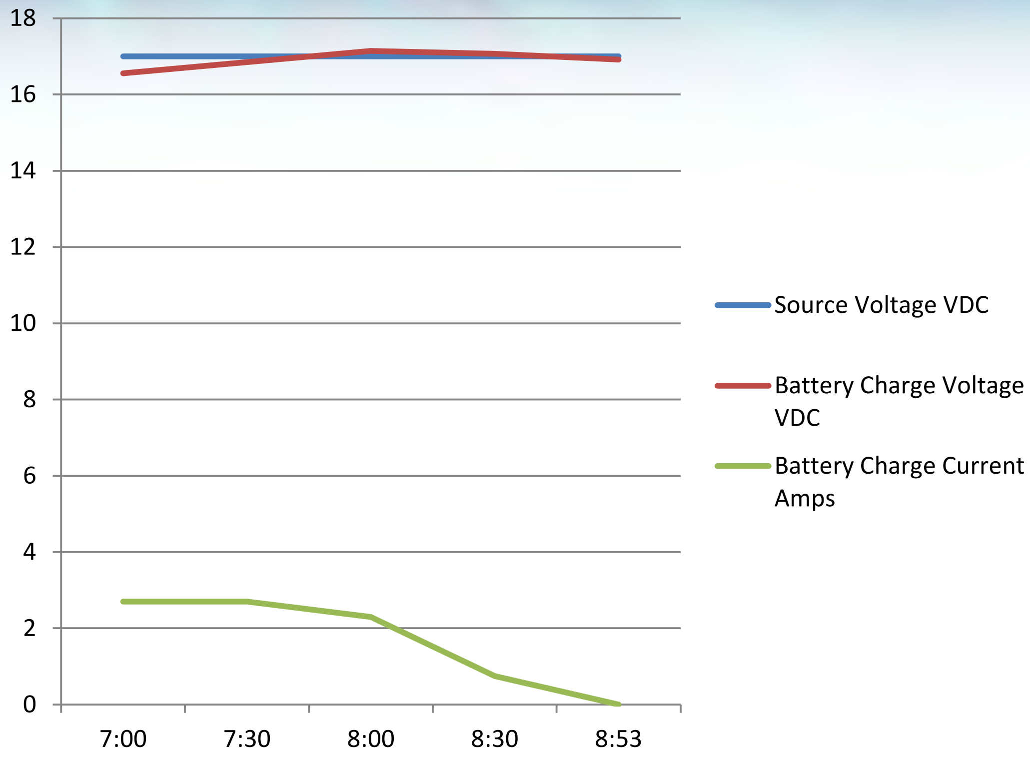
Cell Specific Energy from 250Wh/kg to 275Wh/kg)

HCS TECHNOLOGIES

ABSL POWER SOLUTIONS

An EnerSys Company

Test Data



Test Battery, BB2590 was taken to a full charge and then discharged with a .5 amp load for 8 hours. Then a controlled charge using the Soldier Portable Charger (SPC). Charge time was 1 hour and 53 minutes, the SPC output at the beginning of the charge was 16.56 VDC. The SPC voltage gradually adjusted higher to maintain a higher charge current, which allows for a faster charge.

An EnerSys Company

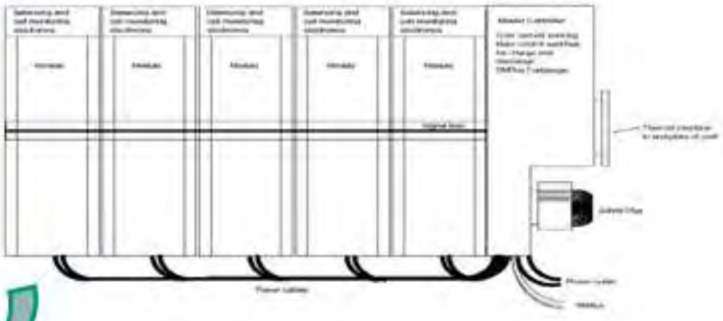
Extending the Power Spectrum

DoD Statistics

- 300W continuous power replaces one small genset.
- One combat brigade uses 1/2 million gallons fuel per day
- One 60kW genset uses 4-5gal per hour - $700,000/yr for fuel
- Solar could reduce by 30% to 50% current FOB fuel costs

An EnerSys Company

Mobile Power Station



Summary of the HEDBS Performance Characteristics
The 5 modules plus the battery management unit would have the following estimated performance characteristics:

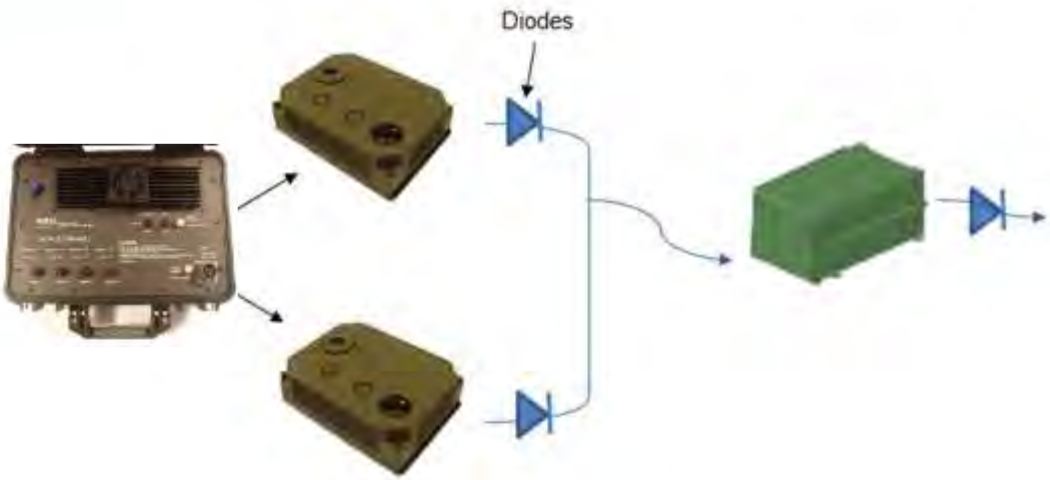
Length: 480mm
Width: 350mm
Thickness: 220mm
Weight: 90kg

Nominal Voltage: 25VDC
Nominal Capacity: 100Ah
Specific Energy: ~139Wh/kg
Energy Density: ~340Wh/l

An EnerSys Company

High Energy Charging

Two SPCs Charging Each of Five Battery Modules



Two SPCs in parallel will provide a charge current of 20A at 29.4VDC

With a nominal 93% efficiency, each SPC will need a minimum of ~630W to charge at the C/5 rate (20A).

Over a 24 hour period, depending on the required average discharge power, each module would need a nominal input energy of:

- At 300W discharge (with 5 modules): 1.4kWh per module
- At 500W discharge (with 5 modules): 2.4kWh per module

Over a 10 hour charge period the two SPCs could deliver a nominal energy of ~5kWh. This is twice the energy required to fully charge a 'flat' module in a 10 hour period at a C/5 charge rate, which would allow for days when full output from the solar panels is not available.

An EnerSys Company

Modular Storage Battery

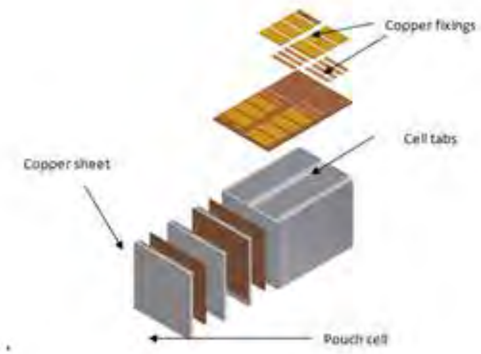


Figure 1: Representative Cell Stack Assembly

A 2.5kWh will stack will consist of 7 cells in series at 100Ah

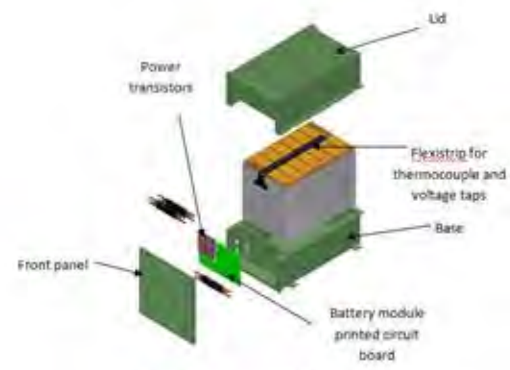
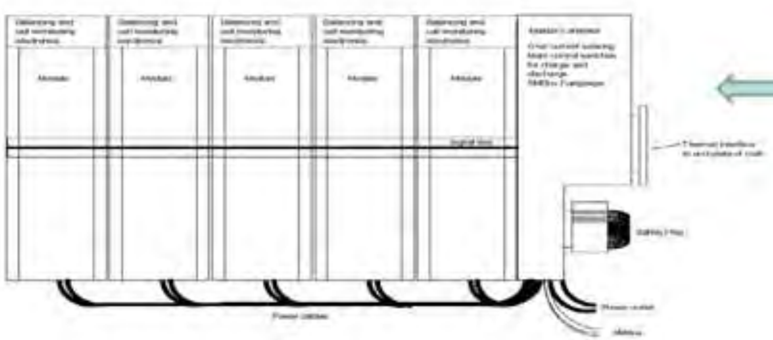


Figure 2: Representative Module Assembly



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Summary

Smart Portable Charger – will harvest/scavenge energy from any DC source

wind; solar; vehicle power sources; primary or secondary batteries

11Ah X590 - 210Wh/kg

maximize energy storage per unit weight

Custom pouch cell technology

up to 275Wh/kg specific energy in cells

light weight modular design – 2.5kWh per LRU

Currently evaluation various solar collectors for use in portable kits

An EnerSys Company

US ARMY RDECOM

U.S. Army Research, Development and Engineering Command

CERDEC

US ARMY – RDECOM

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Solar Photovoltaic for Tactical Applications

Cao Chung, US Army CERDEC Renewable Energy Team

Presentation to Joint Service Power Expo 2011

04 May 2011, Myrtle Beach, SC

Contents

Army Applications

- Soldier and Sensor
  - Soldier: Reconnaissance and Surveillance
  - Sensor: Perimeter or Border Security
  - Applicable to 8 hour, 1 day, 3 day, and 7 day missions
  - Need: Prime power and Battery recharging
- Hybrid
  - Remote Power and Silent Watch
  - Tactical Operations Centers (TOC)
  - Need: Logistic Savings and Mission extension

US ARMY RDECOM

Renewable and Alternative Energy Products

CERDEC US ARMY – RDECOM

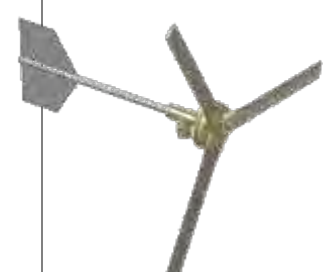
Timetable	FY10	FY11	FY12	FY13
DLA / GSA / PM SWAR		ARRA / C4ISR OTM		C4ISR OTM
PM MEP / PM CP		HI-Power Demos	ARRA/SBIR, SBIR	HI-Power Demos
PM Tactical Vehicle / PM HTV		TTI M915	SBIR	
PM FSS	Net Zero Plus JCTD	ARRA		

Encampment Waste to Energy & Biofuel
Beginning TRL 4; End Goal TRL 6
METRICS: 50 gallon biofuel per ton waste, 25 gallon per day fuel synthesis

Tactical Idle Reduction Equipment
Beginning TRL 6; End Goal TRL 7
APU METRICS: 5 kW, < 600 lbs, < 0.6 gph
ECU METRICS: 1 RT at 125 F in / 90 F out
TTA Status: Signed

Portable Solar Photovoltaic (PV) Modules and Mobile Hybrid PV Power Sources
Beginning TRL 3
FY11 Goal TRL 5; FY13 Goal TRL 6
METRICS: 35 W/kg, 150 W/m2, $2.50/W

Wind Turbines and Deployment Structures
Beginning TRL 3; End Goal TRL 5
METRICS: 100 W at 20 mph, 45 lbs stowable system including MPPT and power electronics



Heat Actuated Cooling and Cogeneration Systems
Beginning TRL 3/4; End Goal TRL 5
METRICS: COP 0.7, 45 kg/ton

US Army CERDEC Solar PV Module Level Objectives

All performance metrics reported for AM1.5 insolation and standard, temperature, and pressure (STP) ambient conditions.

	Current	Threshold	Objective	Pacing Technology
Architecture	Foldable Rigid Ruggedized Thin Glint Free* Rollable*	Foldable Flexible Ruggedized Thin Glint Free Rollable Chemically Resistant	Foldable Flexible Ruggedized Thin Glint Free Rollable Chemically Resistant	Packaging Fabrication processes Encapsulation/coating
Power density	35-40 W/kg or 50-80 W/m^2	40 W/kg or 100 W/m^2	75 W/kg or 150 W/m^2	Material selection Novel PV chemistry Encapsulation/coating
Conversion efficiencies	5 to 8 %	10%	15 %	Material selection Novel PV chemistry
Cost	$15 per Watt	$3.50 per Watt	$2.50 per Watt	Material selection Fabrication processes

*Available for certain current technologies.

CERDEC's In House PV Test Results and programs

Sample ID: Unknown Model 11.375” x 6”

- CIGS based technology
- Monolithically integrated
- Roll-to-roll continuous production
- Ascent Solar Specs:
  - P_{max}: 4.0 Watts
  - V_{OC}: 23.8 V
  - I_{sc}: 0.31 Amp
  - V_{mp}: 16.5 V
  - I_{mp}: 0.245 Amp

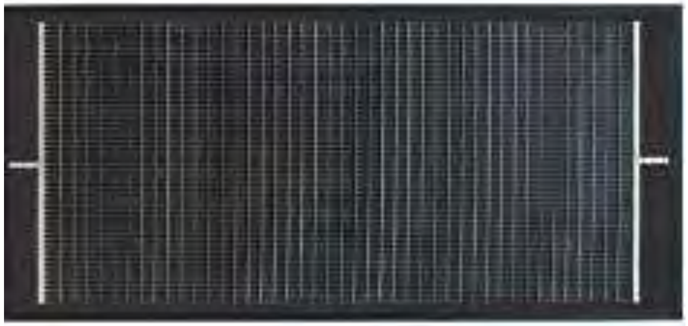


Image courtesy of Ascentsolar.com

- **CERDEC Test Results**
  - Irradiance: 875 W/m^2 @ MP
  - Temp: 95° F, Partly cloudy
  - P_{max}: 3.21 Watts; η : 8.35%
  - V_{OC}: 17.0 V, I_{sc}: 0.271 Amp
  - V_{mp}: 14.5 V, I_{mp}: 0.189 Amp

Sample ID: PowerFilm Rollable R15-300


Image courtesy of Powerfilmsolar.com

- Amorphous Silicon base semiconductor
- Monolithically Integrated
- Roll-to-Roll production
- PowerFilm Specs:
  - P_{max}: 7.0 Watts
  - V_{OC}: ?
  - I_{sc}: ?
  - V_{mp}: 15.4 V
  - I_{mp}: 0.45 Amp

- **CERDEC Test Results**
  - Irradiance: 692 W/m^2 @ MP
  - Temp: 80° F, Cloudy
  - P_{max}: 6.59 Watts; η : 6.52%
  - V_{OC}: 19.1 V, I_{sc}: 0.524 Amp
  - V_{mp}: 13.0 V, I_{mp}: 0.507 Amp

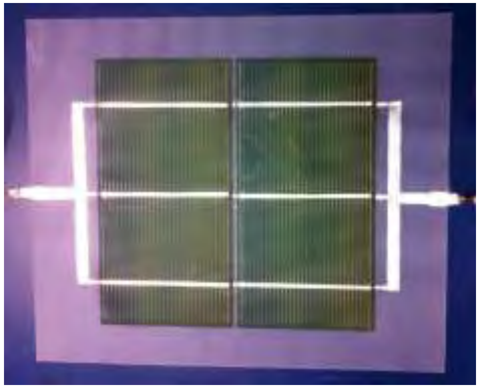
Lite-PM 110 Watts

- Encapsulated crystalline silicon
- Mechanically assembled
- Batch production
- GreenPath Specs:
  - 36 Mono C-Si Cells
  - P_{max}: 110 Watts
  - V_{OC}: 23.76 V
  - I_{sc}: 5.45 Amps
  - V_{mp}: 20.16 V
  - I_{mp}: 5.35 Amp

Image courtesy of GreenPath Technologies

- **CERDEC Test Results**
  - Irradiance: 514 W/m^2 @ MP
  - Temp: 66° F and cloudy
  - P_{max}: 49.6 Watts; η : 12.9%
  - V_{OC}: 23.35 V, I_{sc}: 2.87 Amp
  - V_{mp}: 18.9 V, I_{mp}: 2.13 Amp

Global Solar Energy SecGen Cell - 1



- CIGS based semiconductor
- Mechanically assembled
- CIGS material is roll-to-roll production
- GSE Specs:
  - P_{max}: 4.27 Watts
  - V_{OC}: 1.20 V
  - I_{sc}: 5.90 Amps
  - V_{mp}: 0.846 V
  - I_{mp}: 5.05 Amp
- **CERDEC Test Results**
  - Irradiance: 514 W/m^2 @ MP
  - Temp: 89.6° F, partly cloudy
  - P_{max}: 2.01 Watts; η : 10.3%
  - V_{OC}: 1.13 V, I_{sc}: 4.58 Amp
  - V_{mp}: 0.665 V, I_{mp}: 3.03 Amp

CERDEC's Prior Solar Development

Rucksack Enhanced Portable Power System (REPPS)

- Connects and recharges Li-ion BB-2590 batteries
- Recharge time: 4 to 6 hours
- Rated P_{max}: 62 Watts
- GSE manufactures CIGS solar PV modules and Brentronics is the systems integrator
- Available on the GSA
- 100 have been sent to the field

SunDial Transportable Solar Power System (TSPS)

- Customer: US SOCOM
- Objective: Obtain Safety conf. report by 31 December 2010
- TRL 7, MRL 6
- Benefits: 1 gal/hour of fuel savings
- Specification (COTS Components):
  - 10 kW continuous power
  - 38.6 kW Solar PV arrays
  - 192 kWh lead acid energy storage
  - 7 kW diesel fueled power generator
  - Deployable in 24 man hours
- Follow-on support planned

Images courtesy of Sundial

CERDEC's Current Program
Solar Stik AGSS

- Customer: PM-MEP
- Five solar PV each rated at 90 Watts each
- Energy storage capable of storing 4 kWhrs using VRLA batteries
- 3 kW JP-8 fueled power generator
- 1.8 kW inverter
- Current TRL of 6
- Obtain a safety confirmation by end of September 2011
- Testing in progress @ APG, MD

Image courtesy of SolarStik

Image courtesy of SolarStik

CERDEC/ARL Current Solar PV – CdTe N Doping

- Current commercial CdTe from FirstSolar has 11.0% and costs $0.76/Watt
- ARL's WMRD provide physical characterization services and conducting nitrogen doping experiments with CdTe using ion implantation.
- CERDEC & ARL are pursuing a two-year, two-phase program to advance polymer encapsulated CdTe solar PV.
  - Phase I: developing single-junction CdTe solar cells with threshold of 15% efficiency, 20% target and 75 W/kg
  - Phase II: modeling, simulation, and plant design to demonstrate $2.50/W production cost at 15MW/year and less than $1/W at productions of 1 GW/year

Current commercial CdTe PV

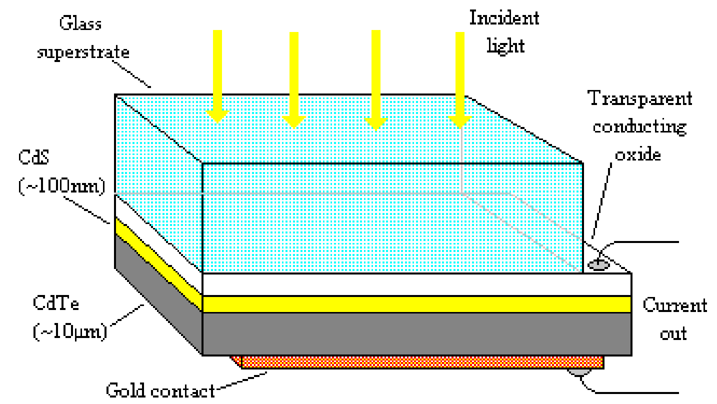
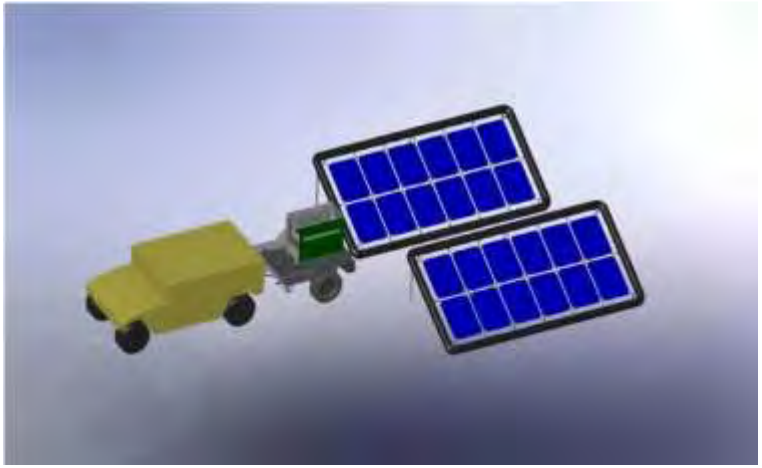


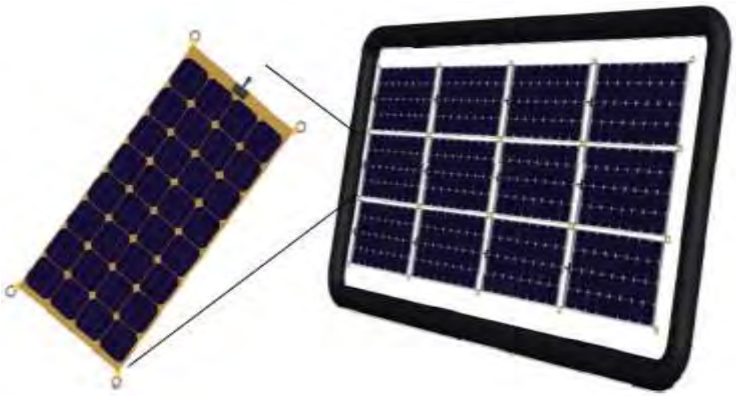
Image courtesy of Durham University, UK

2.5-kW Advanced Solar Power Source



- Objective: 15% efficient solar PV array with 10% threshold
- Deliverables:
  - 5 kW bidirectional inverter
  - 2.5 kW encapsulated c-Si solar PV
  - 12 kWh Li-ion battery bank
  - Inflatable deployment structure
- Electricore Reports: 11.4% module efficiency and power dens. of 50 W/kg
- Demonstration: TBA @ APG, MD

Images courtesy of Electricore



Conclusion

- Technologies Interests
  - Crystalline
  - Thin-film
  - No glass encased devices
- CERDEC's Objective / Focus
  - Power density ≥ 40 Watts/kg
  - $\eta \geq 10\%$
  - Cost ≤ $3.50 per Watt
- Applications
  - Inverters
  - Portable Systems
  - Hybrid Systems

Utilization of a Ducted Wind Turbine in a Trailer Mounted Renewable Energy Micro-grid (TREM)

May 4, 2011

Mark Matthews
Vice President of Sales and Marketing
WindTamer Corporation / Arista Power

WINDTAMER
Bringing wind power down to earth.™

ARISTA power

TREM System for CERDEC

Goal of TREM

- First unit delivered to CERDEC in fall of 2010
- Focused on creating a 2 to 5kW system maximizing the wind resource
- Energy storage to eliminate renewable energy variability
- Customizable to maximize renewable resource at a given location

Overview of Initial System

- A mobile renewable power system platform utilizing a 4.5BT-500 Turbine as primary power source.

- First generation system leveraged commercial off the shelf components in conjunction with some required custom designed components which will allow for an efficient and economical initial solution.

- The target design of the system solution will be to provide a platform capable of accepting a wide range of voltages and therefore greater options with regards to power generation sources.

Trailer Components

- Power creation
  - Ducted Turbine
  - Solar PV
  - Generator / Grid

- Energy Storage
  - Initial Unit with 14kWh of VRLA

- Power Distribution
  - Multiple AC and DC outputs and voltages

WINDTAMER
Bringing wind power down to earth.™

ARISTA power

WindTamer Ducted Turbine

VIDEO

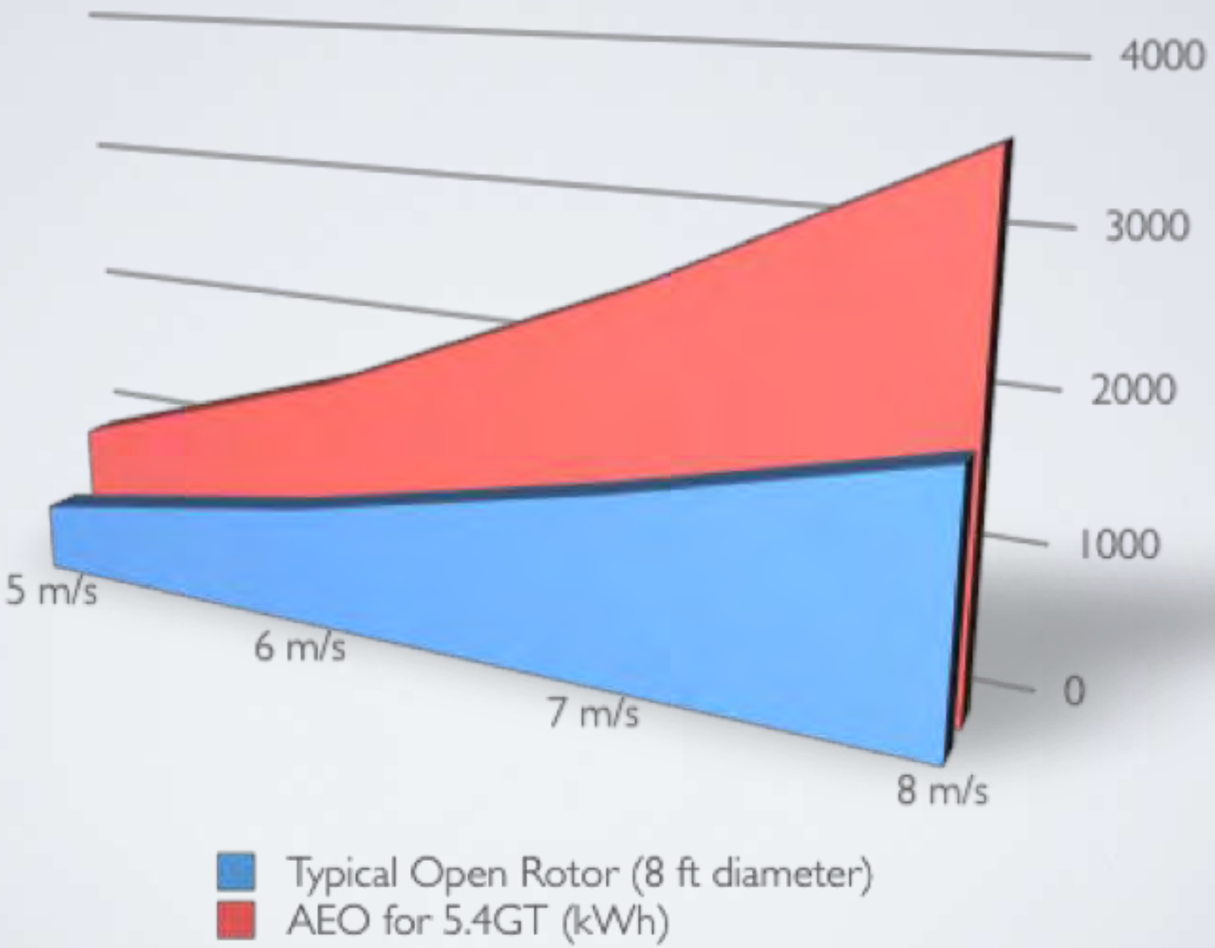
- To be included on CD at show

Patented Design

Patent: Fluid Driver Vacuum Enhanced Generator

- Design uses the wind to induce rotation just as conventional wind mills
- Utilizes a sophisticated bypass system that harnesses one vacuum that forms internally behind the blades
- Second vacuum that forms externally to assist rotation

4.5GT AEO



4000
3000
2000
1000
0
5 m/s
6 m/s
7 m/s
8 m/s
Typical Open Rotor (8 ft diameter)
AEO for 5.4GT (kWh)

Advantages of Ducted Turbines

- Low Noise Operation
- Minimal maintenance – 2 moving parts
- Safety – No open spinning blades
  - There is no danger of blade throw or ice build up
- Enhanced efficiency of available wind power over open rotor systems
- Real-time monitoring and braking to insure system safety and maximum energy generation

Solar PV

- Wind and Solar are an excellent compliment
- Configurable to energy creation scaling
- Initial system utilized thin film solar PV
- More recent systems incorporate ruggedized monocrystalline panels for maximum efficiency.

Energy Storage and Power Distribution

- 16 Batteries PowerSonic VLRA: 14.2kWh total storage
- Designed Capacity of 7.2kWh: Limit VRLA to 50% to maximize cycle life
- Maximum AC Discharge of 2kW
- Maximum DC Discharge of 600W

Input Power

Source	Voltage	Rating
Wind Turbine	Variable: 0 to 55VDC	.40-.45 efficiency from available wind
Solar Panel	15VDC, 110 Watt	85%, 6hrs optimal light
AC	Shore Power (AC direct from utility source of generator)	120 VAC

Output power

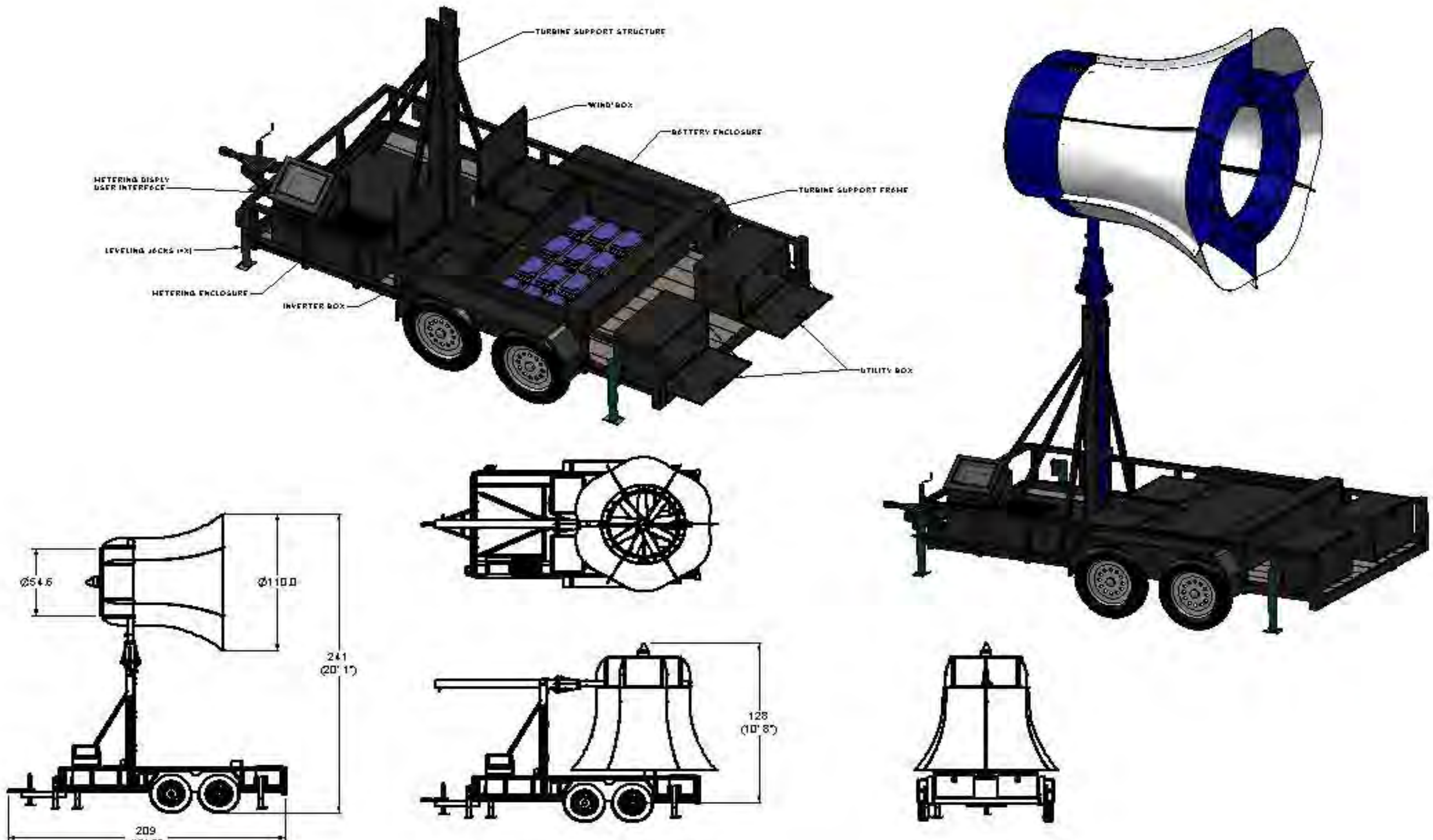
Power Type	Max Power Rating	Current Rating	Connection Options
120 VAC	2000 watts	30 amps (2 15A breakers)	4 GFI outlets
12 VDC	300 watts (100 W ea. outlet)	10 amps each connector	3 Cig style outlets
28 VDC	300 watts	30 amps (fuse)	4 pin weather proof connector

Mechanical Overview

- System Mounted to 6'8" x 14' tandem axle trailer
  - Tube rail, wood deck, jack with autoleveling
- Custom and Pre-Fab Cabinets vented for battery, electronics and additional storage
- COTS Winch System
- Weight Distribution Balanced for towing and stability
- Interface Controls
  - Favor Driver side of trailer
  - Basic gauging + monitoring

WINDTAMER
Bringing wind power down to earth.™

ARISTA power



TEST UNIT IN RAISED(PARKED) POSITION

TEST UNIT IN LOWERED(TRAVEL) POSITION

Unit Validation

Charge Time based on Wind Speed (need 7kWh to charge 50% depleted battery)

Wind Speed (mph)	Solar (6 hr Raidiation)	Wind Output 24 Hours	Recharge Time from only renewables
12	75W/h	75W/h	81 hrs
16	75W/h	200W/h	30 hrs
20	75W/h	400W/h	16 hrs
24	75W/h	600W/h	11 hrs
28	75W/h	800W/h	8 hrs

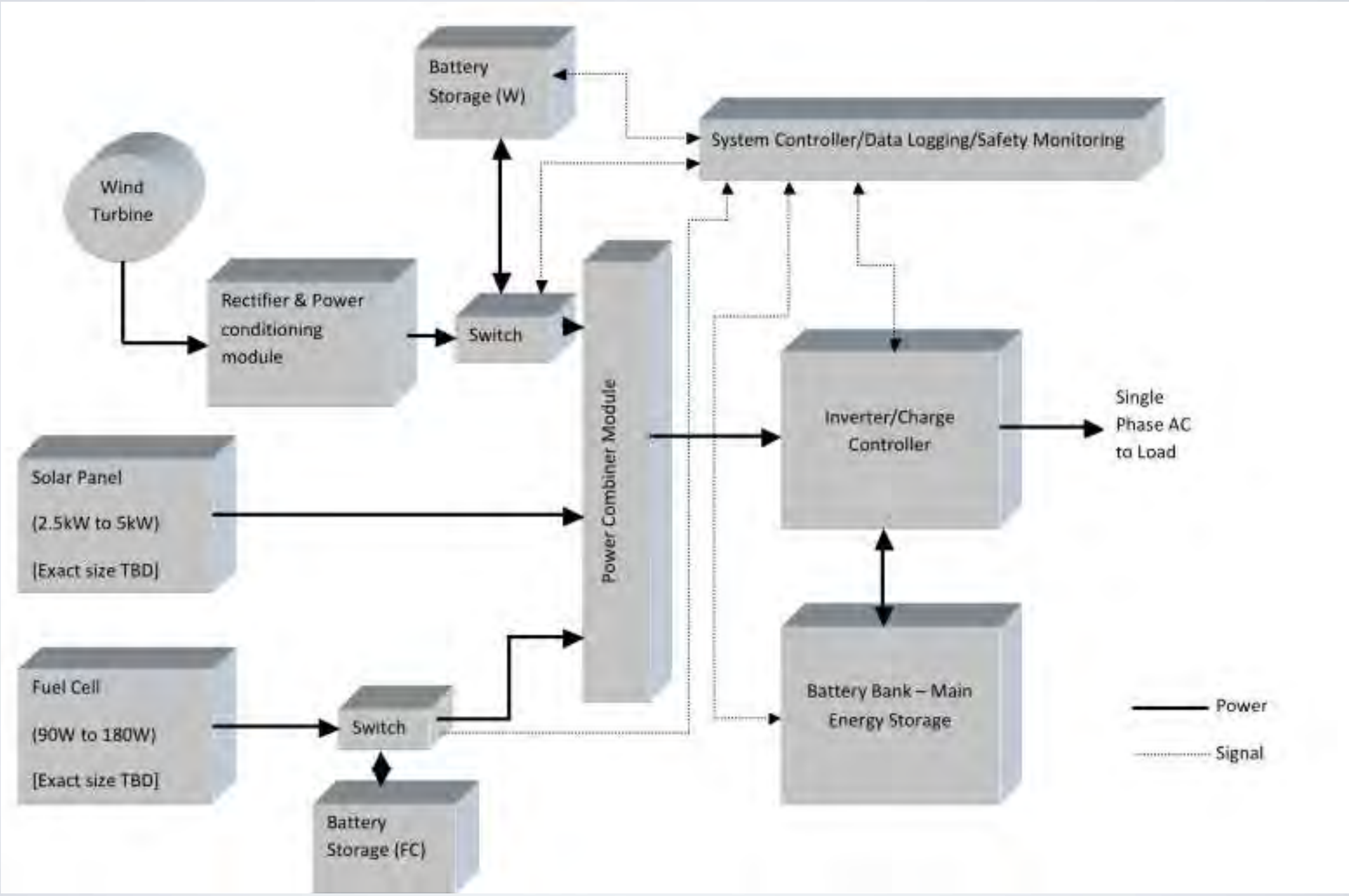
Testing of unit continues at Aberdeen Proving Grounds

Usage Savings versus Generator and JP8

- No requirements to provide logistic fuels (renewable energy)
  - Fewer people delivering fuel (cost and safety)
- 10kW Generator Uses 10 to 15 gallons of JP8 per day
- At $15 per gallon annual savings of $121,667 in JP8 alone

Future Iterations / Learning from Initial Build and Testing

Revised System Architecture



Energy Generation

- Wind Turbine
  - 5.4BT-500
  - Multiple micro-turbines 300 to 500 watts
  - Increase efficiency reduce duct size and weight
- Solar PV
  - Rapid deployable / ruggedized 230W to 250W panels
- Fuel Cell
  - Smart Fuel Cell EVOY PRO 2200 XT

Energy Storage /Power Distribution

- Chemistry Agnostic based on system requirements
  - Lithium Ion, Lead-Acid and NiMH
  - Based on application requirement
    - Temperature
    - Cycle Life
    - Cost
    - Weight
- Power Distribution from 1kW to 1MW
- Scalable from Mobile Unit to Commercial Building

Mechanical / User Interface

- Ruggedization for each environment / applications
- Telescoping pole for various turbine heights
- Integration of remote monitoring capabilities
- Various Deployment Versions:
  - Permanent off trailer with parallel capabilities for larger installation
  - Rapid Deployment
  - Semi-mobile with larger solar array

Thank You

Systems approach to OBVP Requirements

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Systems approach to OBVP requirements

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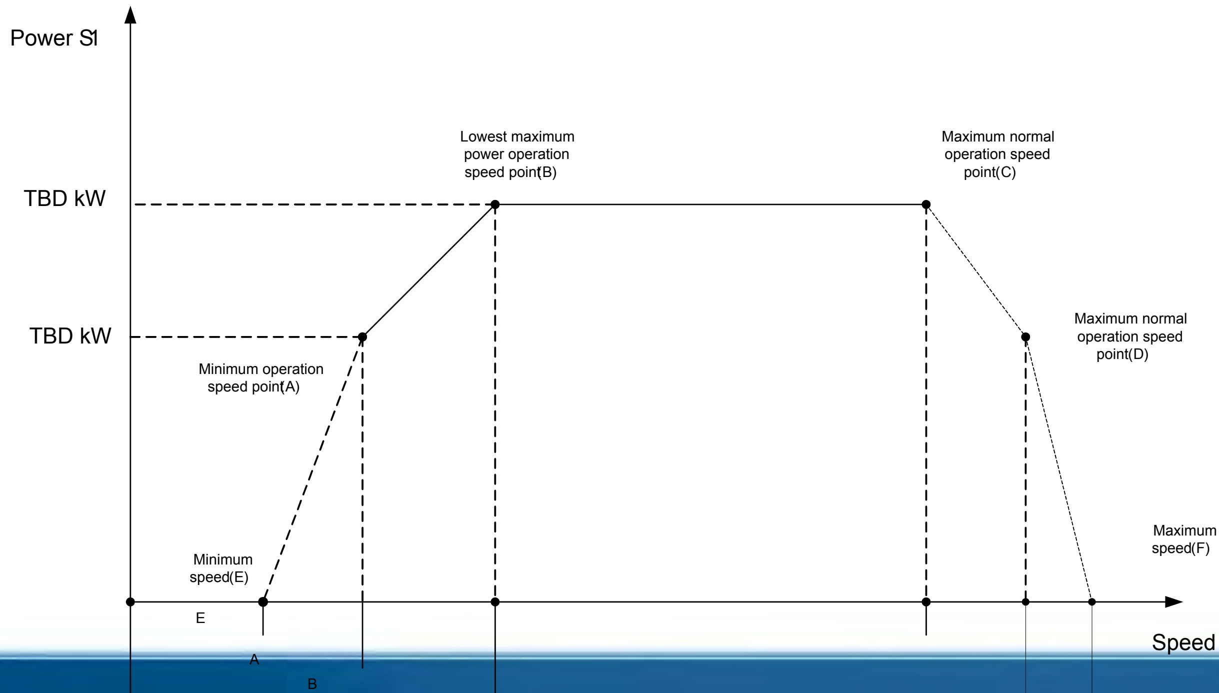
Topics

- Kollmorgen Background
- TARDEC FED Program
- OBVP Power requirements
- Example “working the HUMPBACK curve”



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Disruptive Innovation – for OBVP

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The Need

•Military vehicles need more on board 28VDC electrical power – up to 30kW

•The needs exceed capabilities of existing low voltage alternators

•High Voltage systems (300VDC to 600VDC) are expensive, require significant package space, are heavy, and have safety concerns

Mine Resistant Protected Vehicles (MRAP)

Combat vehicles

Tactical Vehicles

More Electrical power needed for:

•Communications systems

•Computers

• Mine protection systems

•Threat detection

•Weapon stations

The Kollmorgen Solution

Generates 30kW at the voltage the military needs 28VDC

Platform approach that is Modular/flexible

Saves weight, space, cost and operates at safe voltage

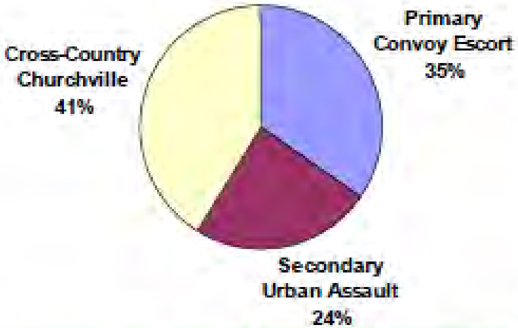
Leverages adjacent KM market technology (lift truck) electronics and KM expertise in motor design

- **Game Changer for OBVP**
  High power (30kW)
  at low voltage (28VDC)
- Modularity: 20-60kW systems
- Belted, PTO, In-line generators with common power electronics/controller

KM provides a solution that uniquely and efficiently meets a need

TARDEC Fuel Efficiency Demonstrator (FED) Program

- Kollmorgen Generator and Generator Controller
- 150 lb weight savings
- 30kW 28 volt ISG



	(hr)	(min)	(sec)
Moving	14	840	50400
Idle	6	360	21600
Total Hours	20	1200	72000

Figure 2: Usage cycle defined for the Fuel Efficient Demonstrator Program

Kollmorgen Low Voltage Platform-Flexible for multiple Vehicle Platforms

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One common controller architecture

28VDC

20 kW belted

30 kW ISG

30 kW belted

50 kW ISG

Systems approach to OBVP requirements

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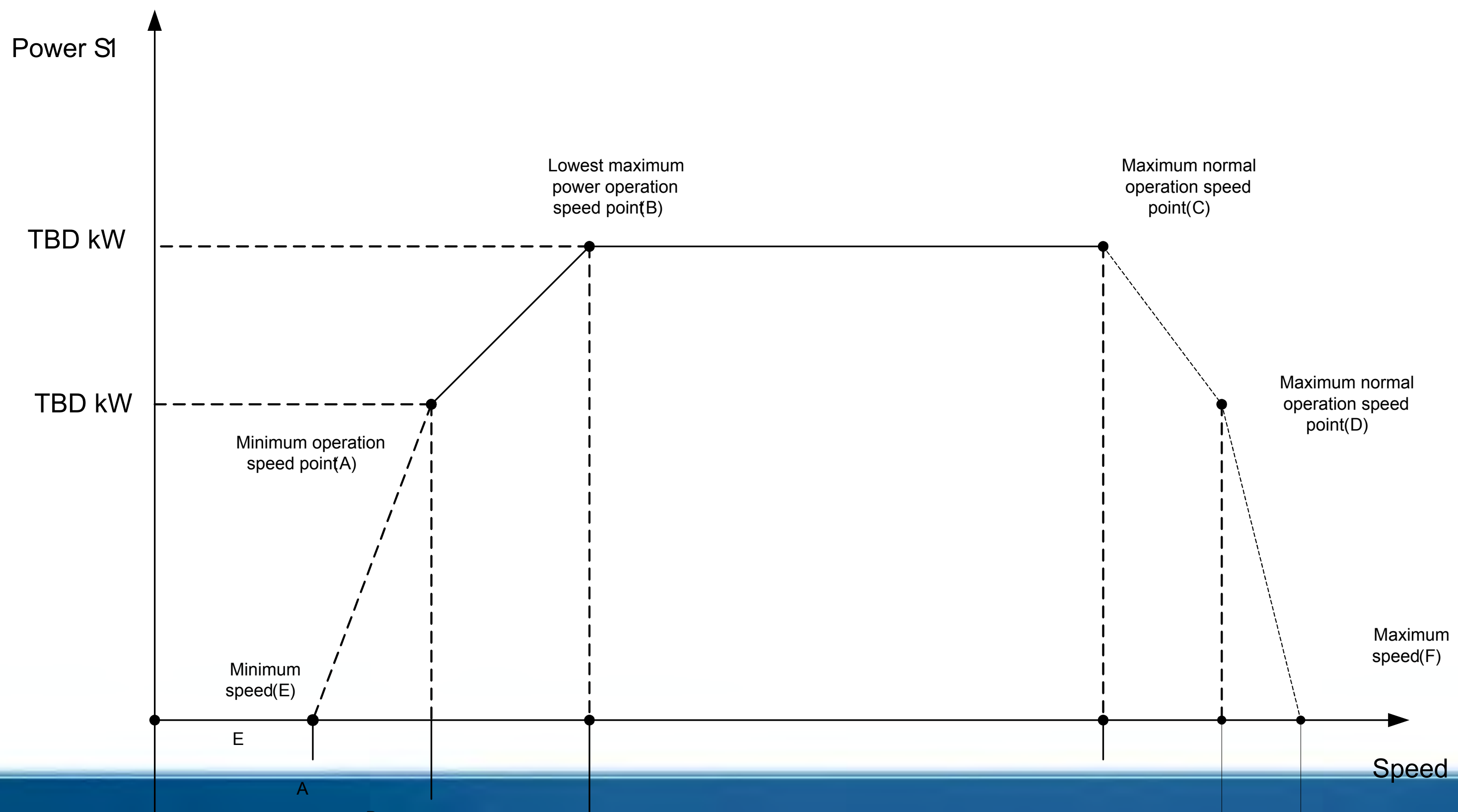
Topics

- Example “working the HUMPBACK curve”



Vehicle Electrical Power

Initial Question – I need more OBVP…….

What Power is requested?

What Engine Speed Range?

What Voltage (28VDC, 300VDC, 600VDC, Multiple voltages)?

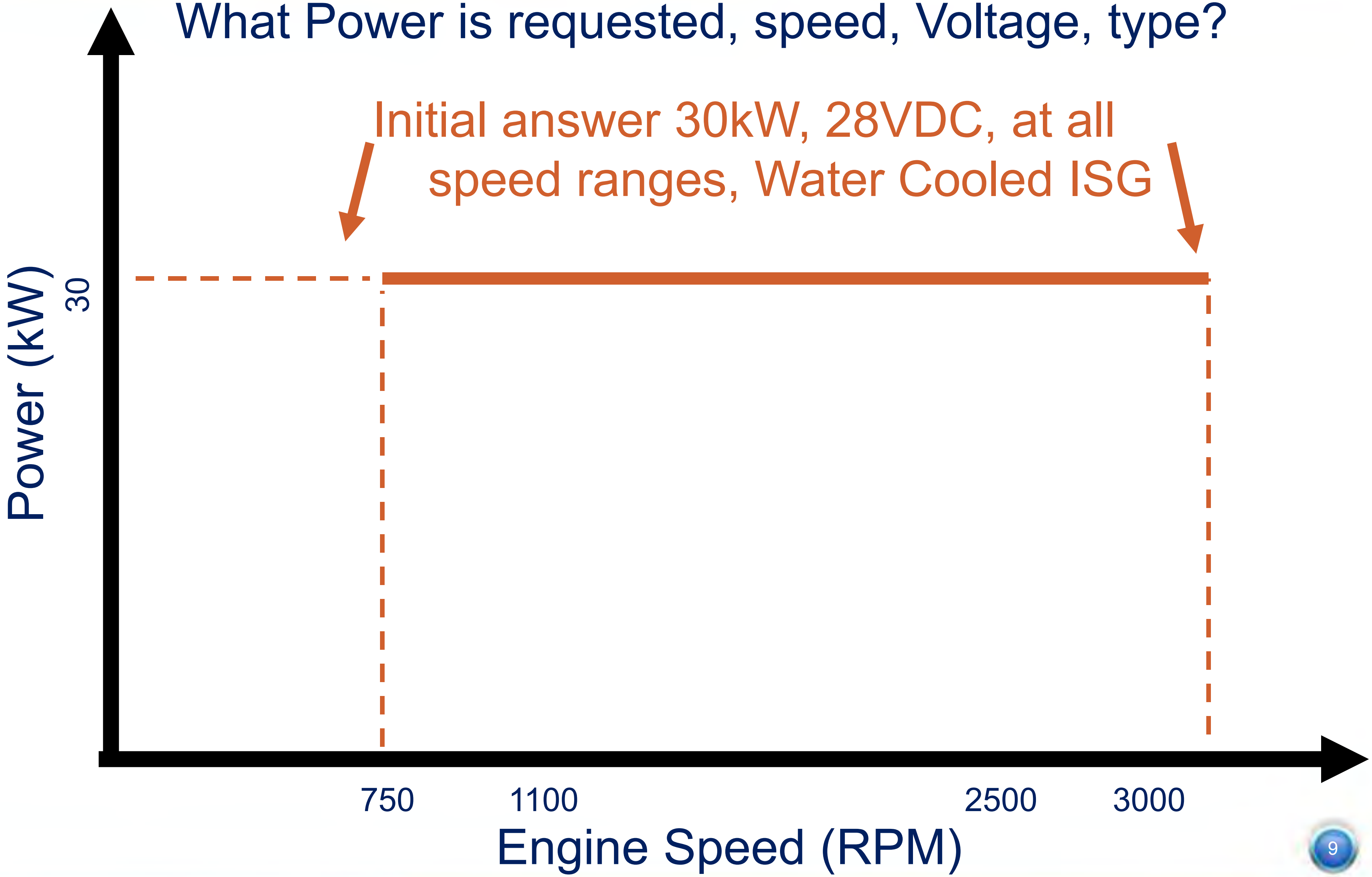
What type of Generator/Motor (IG, Belt driven, PTO, water/air cooled,….)?

Power (kW)

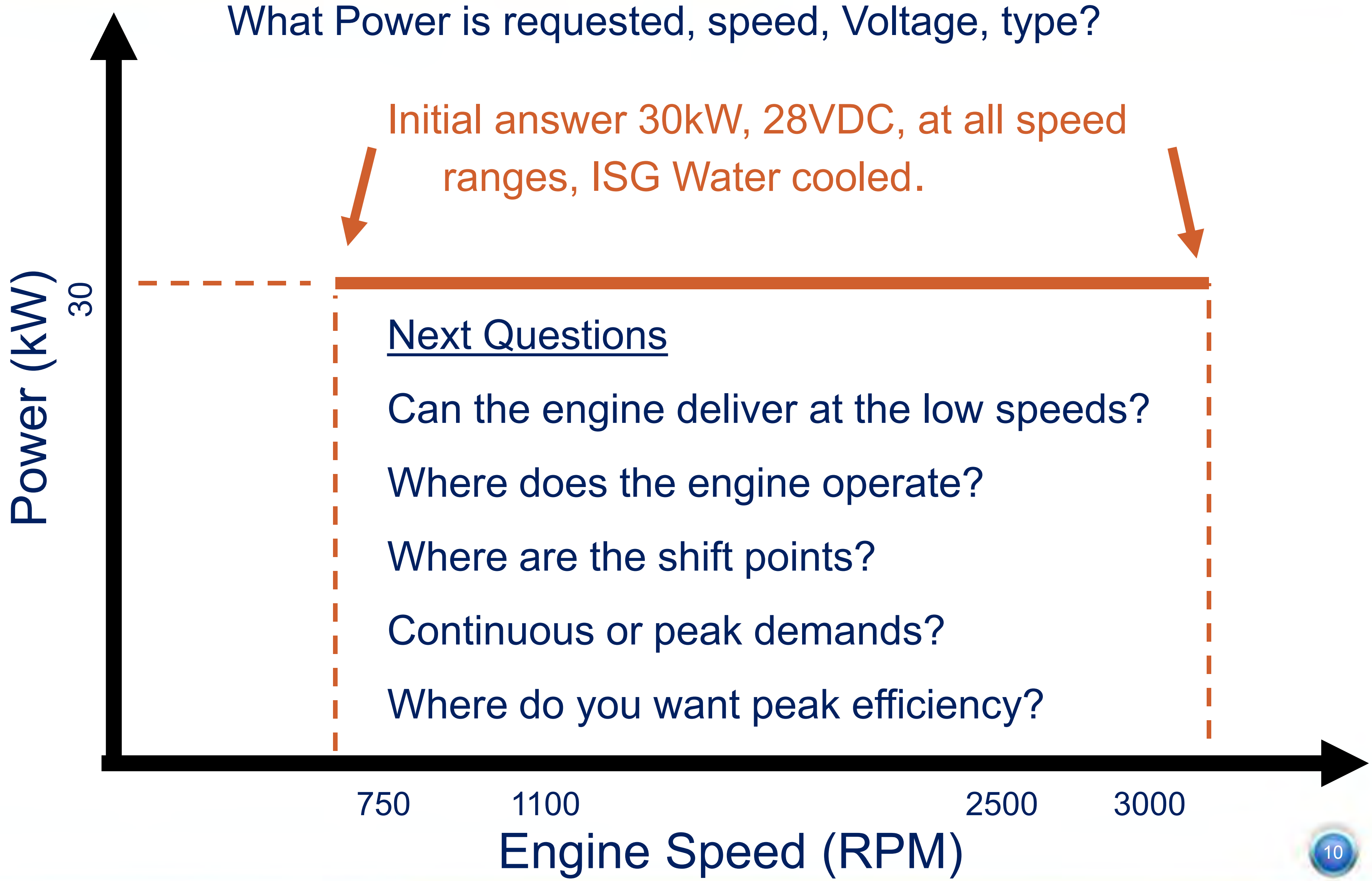
Engine Speed (RPM)

Vehicle Electrical Power

What Power is requested, speed, Voltage, type?



Vehicle Electrical Power



Vehicle Electrical Power

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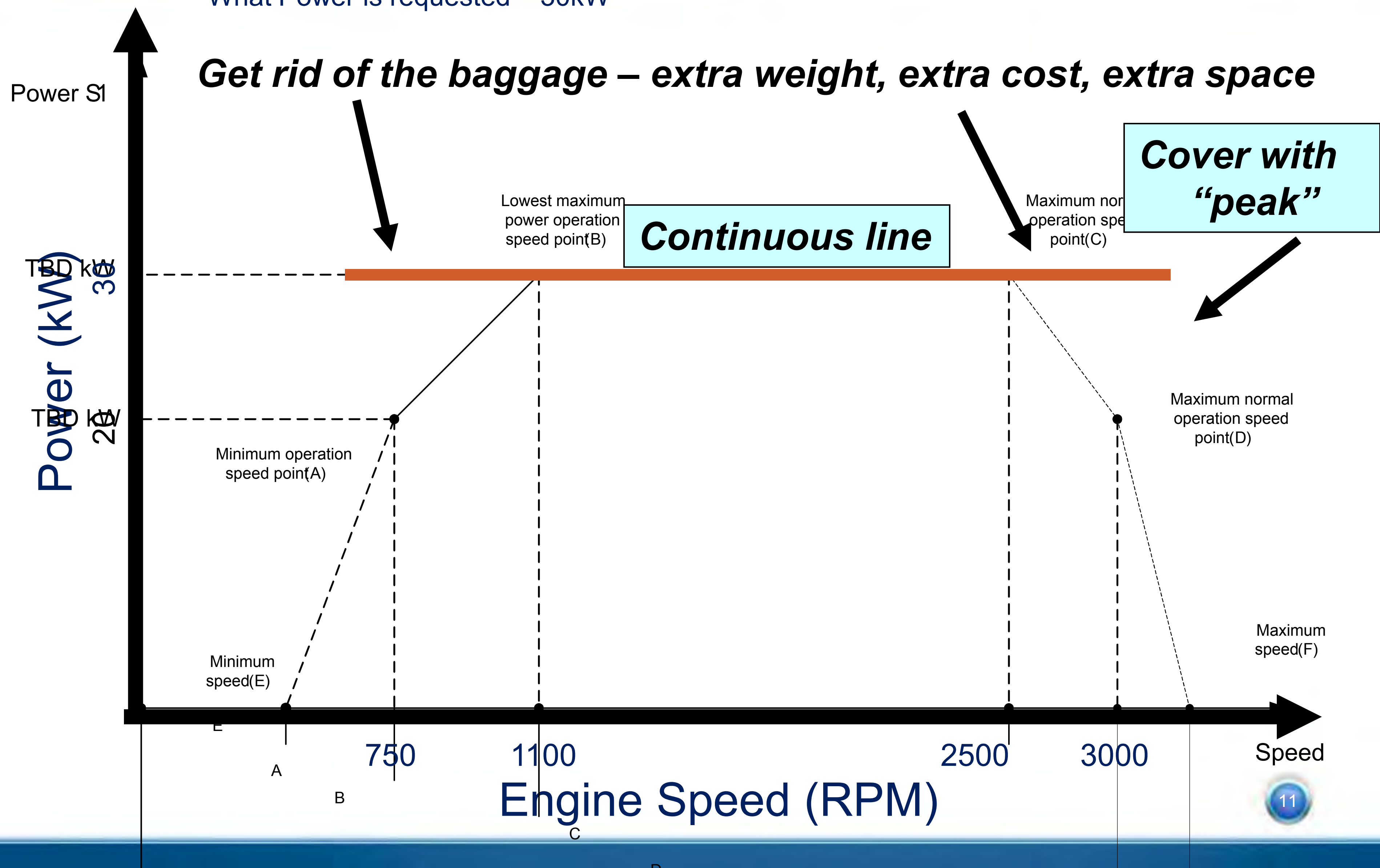
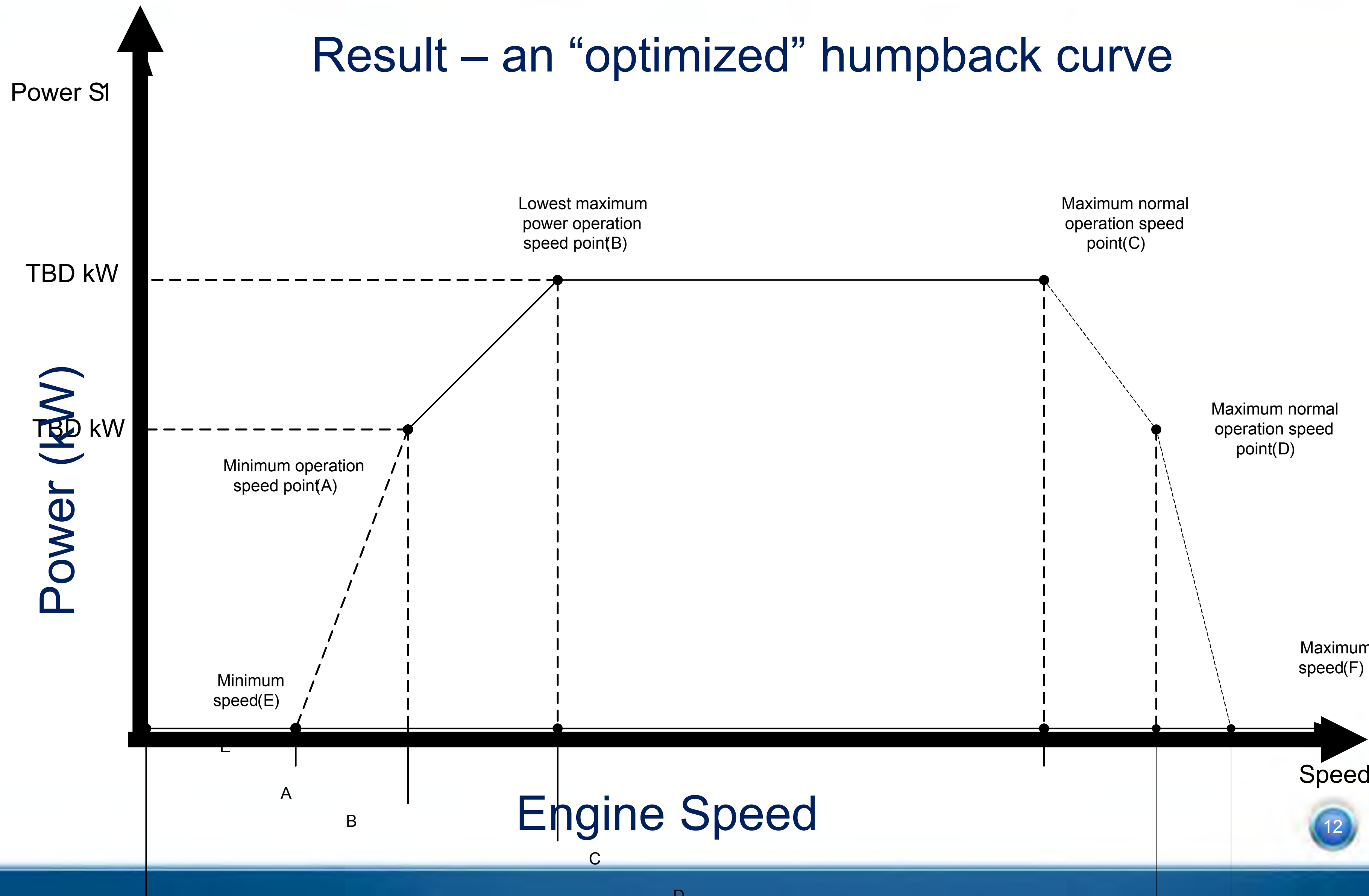
What Power is requested – 30kW

Get rid of the baggage – extra weight, extra cost, extra space



Power diagram result

Result – an “optimized” humpback curve

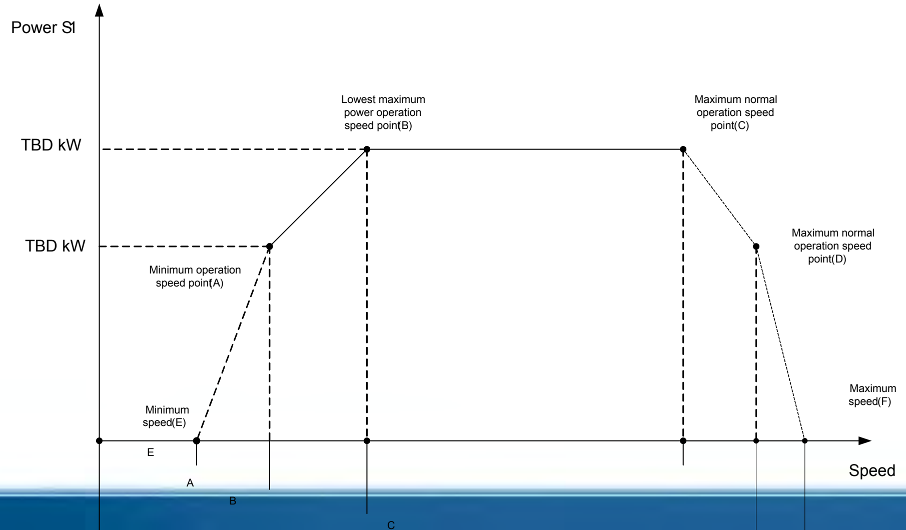


Systems approach to OBVP requirements

- Kollmorgen Background
- TARDEC FED Program
- OBVP Power requirements
- Example “working the HUMPBACK curve”

Take Aways

- Systems approach – generate the power at the voltage the consumer needs – 28VDC may be the most efficient approach (less than 50kW)
- OBVP Requirement – more than just a stated kW – multiple points



Thank you -

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Dan Cowan

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Business Development Manager

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www.kollmorgen.com

Modeling and Simulation of an OBVP Enhanced Vehicle to Improve Fuel Economy\On-Board Vehicle Power: Past, Present and Future”

Presented to

2011 Joint Service Power Expo

Session 16, May 4, 2011

by

Gary Grider, DRS

Mike Mimnagh, ONR

Eric Mog, DRS

ONR Revolutionary Research . . . Relevant Results

Hybrid Assist Program

DRS TECHNOLOGIES

OBJECTIVE:

Upgrade the existing ONR OBVP vehicle by adding bi-directional power converter and energy storage.

MILITARY RELEVANCE/OPERATIONAL IMPACT:

The hybrid assist capabilities can improve fuel consumption and can augment the capabilities of the vehicle during mobility. The added energy storage will significantly extend silent watch capabilities.

NAVAL S&T FOCUS AREAs ADDRESSED:

Platform Mobility and Power & Energy

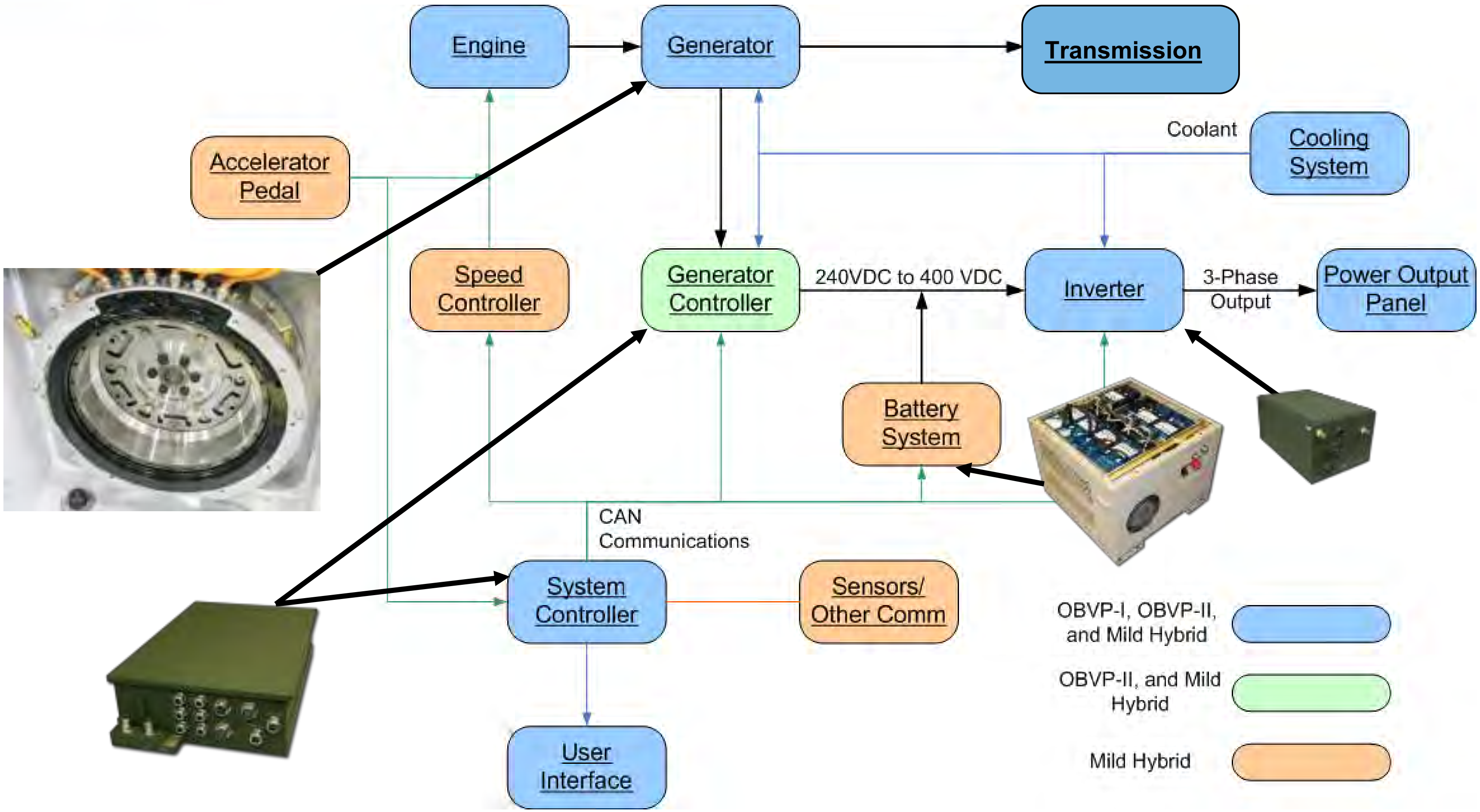
TECHNICAL APPROACH:

The existing ONR OBVP vehicle will be upgraded by replacing the boost-converter power supply with a state-of-the-art Generator Controller (GSC) and Li Ion energy storage. The internal combustion engine control will be upgraded to support using the generator as a motor to assist the vehicle mobility to improve fuel consumption. The hybrid control algorithm will be developed using modeling and simulation and validated with vehicle tests

SCHEDULE:

TASKS	FY09	FY10	FY11	FY12
Conceptual Design	△			
Modeling and Simulation	△	△		
SIL Integration		△	△	
SIL Tests			△ △	
Vehicle Upgrade			△	△
Vehicle Testing				△ △

Proposed Mild Hybrid Architecture



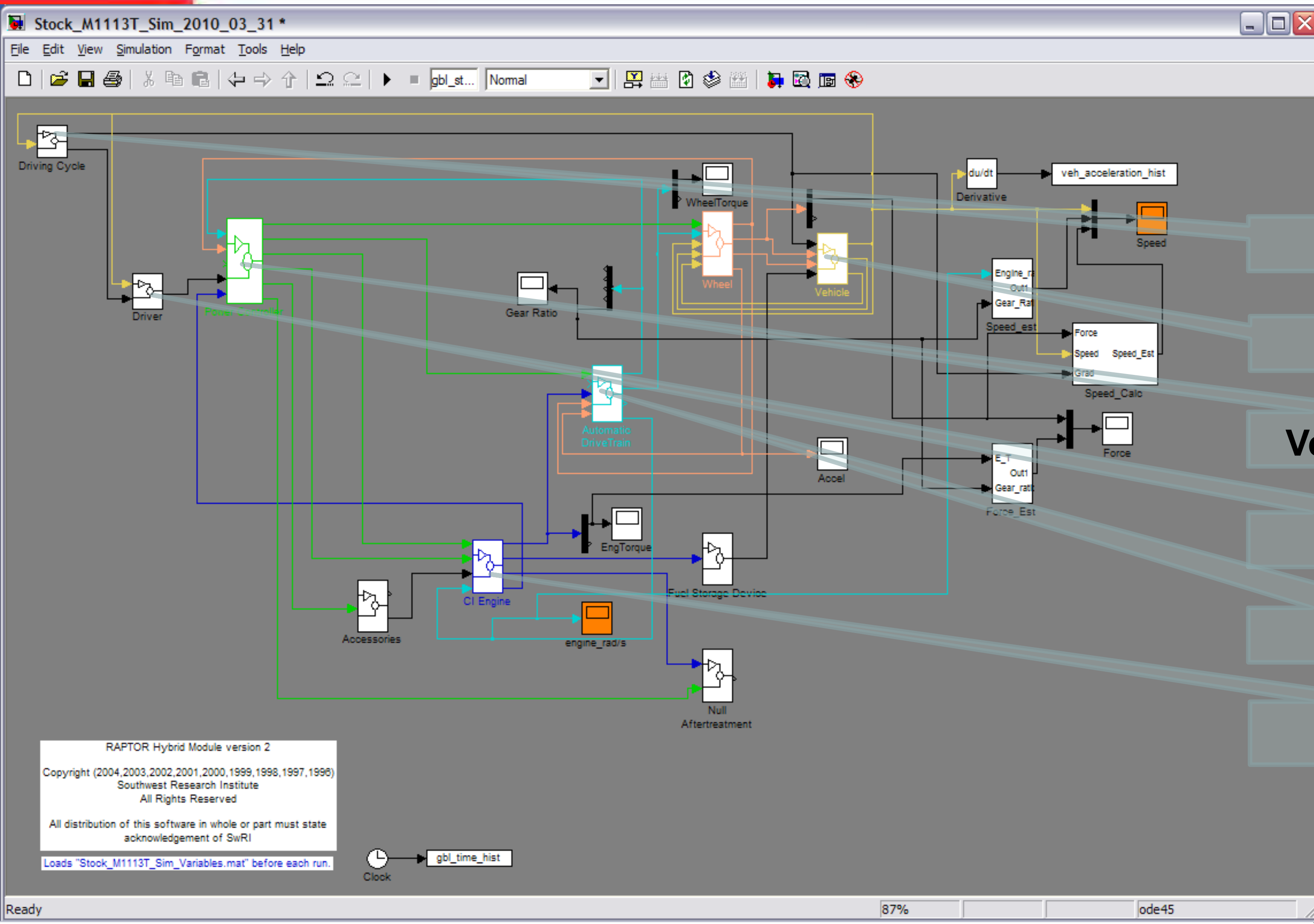
Controller will be identical to USMC HMMWV OBVP hardware developed on DRS IR&D funds. GFE Li Ion battery pack for experimental testing in GFY 11 and 12

Conclusions From GFY10 Trade Study

- Stationary fuel economy (based on vehicle data) can improve in excess of 50% with the inclusion of energy storage
- Software changes, added sensors, a new accelerator pedal, and a new speed controller are needed to perform mobile mild hybrid applications (mobile fuel economy enhancement, torque assist, starting capabilities).
- Trade study shows potential for fuel economy (reference 2010 trade study); more exploration and simulations are needed to determine details of potential improvement.
- If power is required from the vehicle on the move, the mild hybrid capabilities will be reduced. Supplying power is the priority of OBVP.

Trade study verifies that fuel savings can be achieved with a mild hybrid architecture

Stock HMMWV VPSET/Simulink Model



Drive Cycle

Vehicle Profile

Vehicle Controller

Driver

Transmission

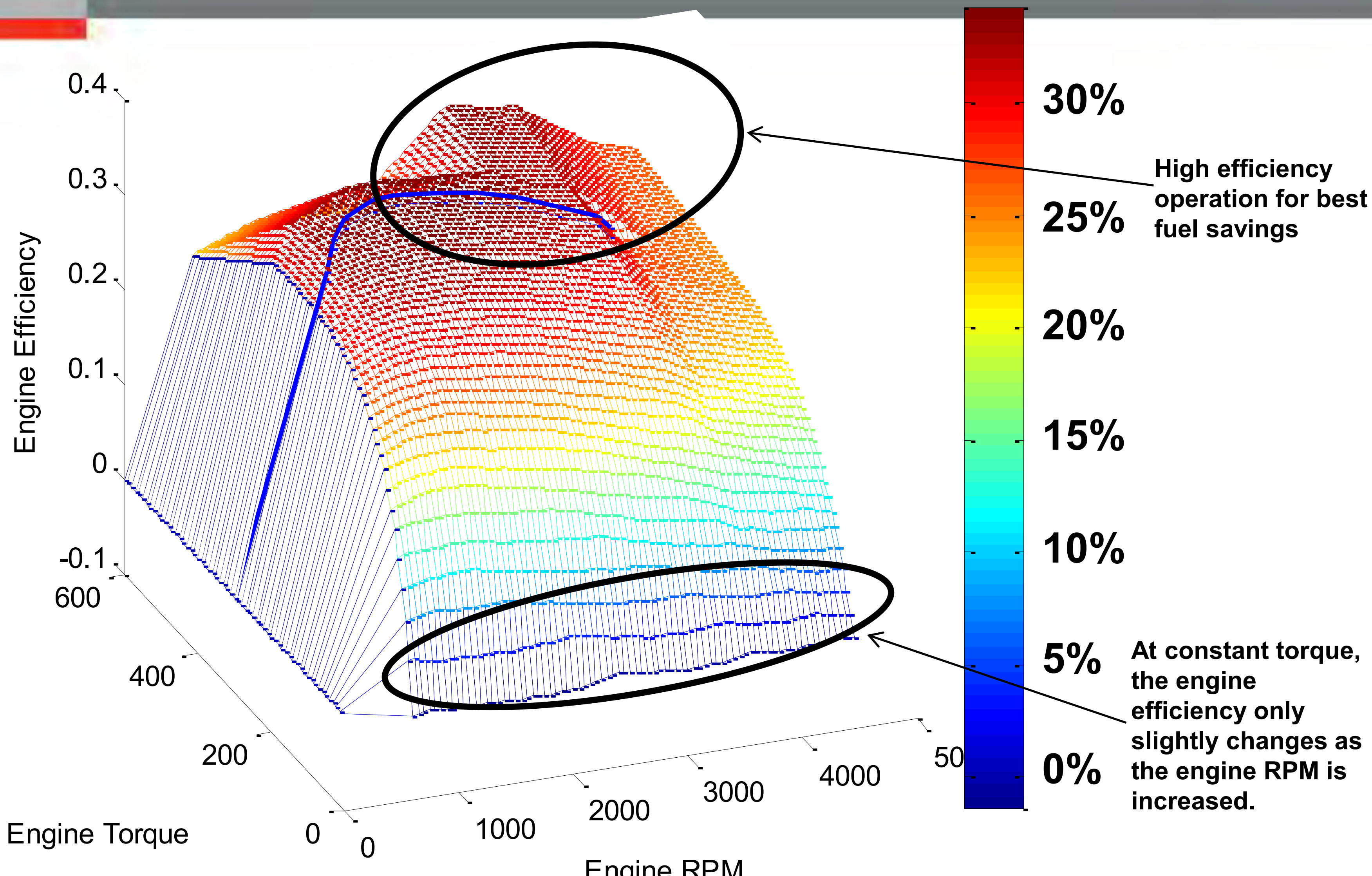
Engine

Stationary Generation Fuel Efficiency

- Currently the vehicle must run at 2000 rpm for every load on the system.
- If energy storage is used, the engine can run at lower speeds based on the load.
- If a higher load is step-loaded, the batteries will take the immediate difference and allow the engine to reach the new speed based on the new load.
- The stationary generation software is the algorithm that will control the engine speed and transfer loads between the GSC and the batteries.

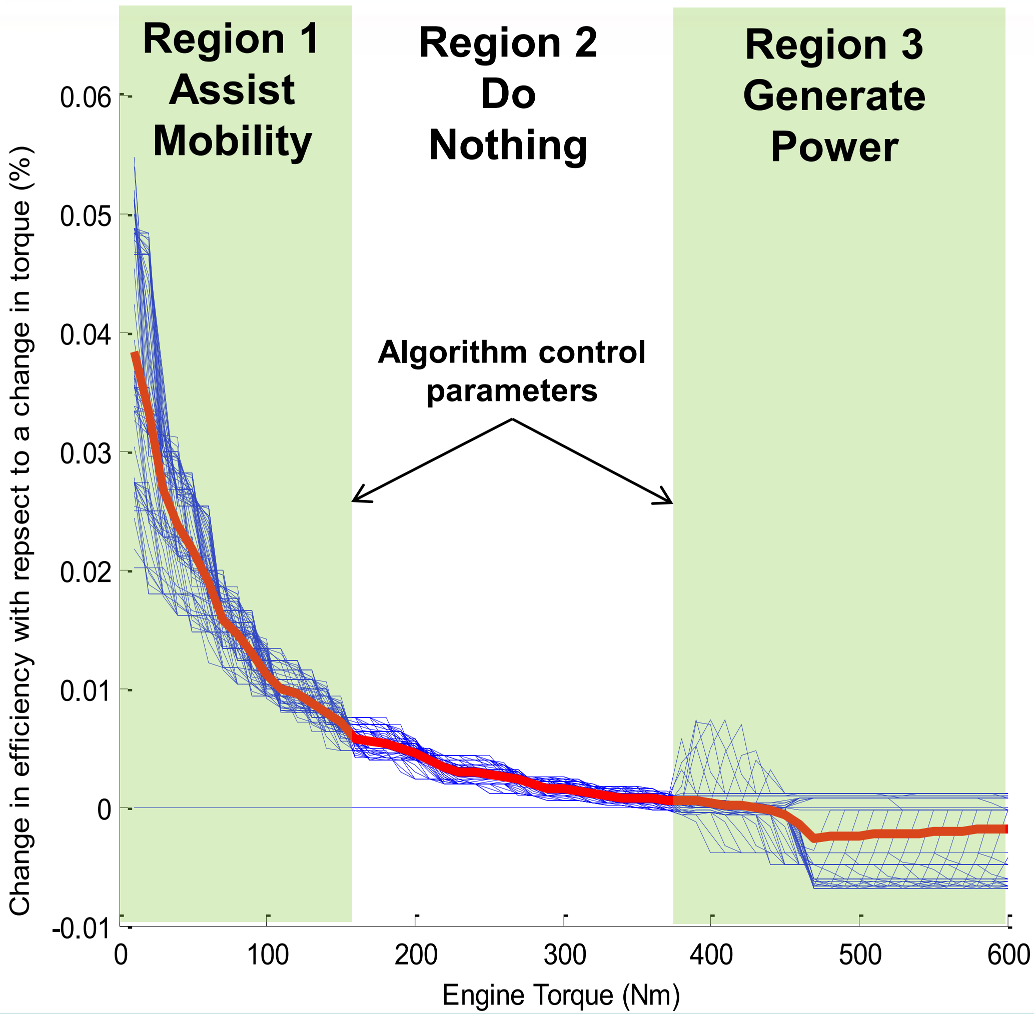
According to data taken from OBVP, the system uses 2.42 gal/hr at 10.2 kW in stationary mode (~2000 RPM) and 1.41 gal/hr at 10.21 kW in mobile mode (~930 RPM). This results in a 41% savings in fuel

Optimizing Engine Efficiency
(Derived from VPSET parameters)



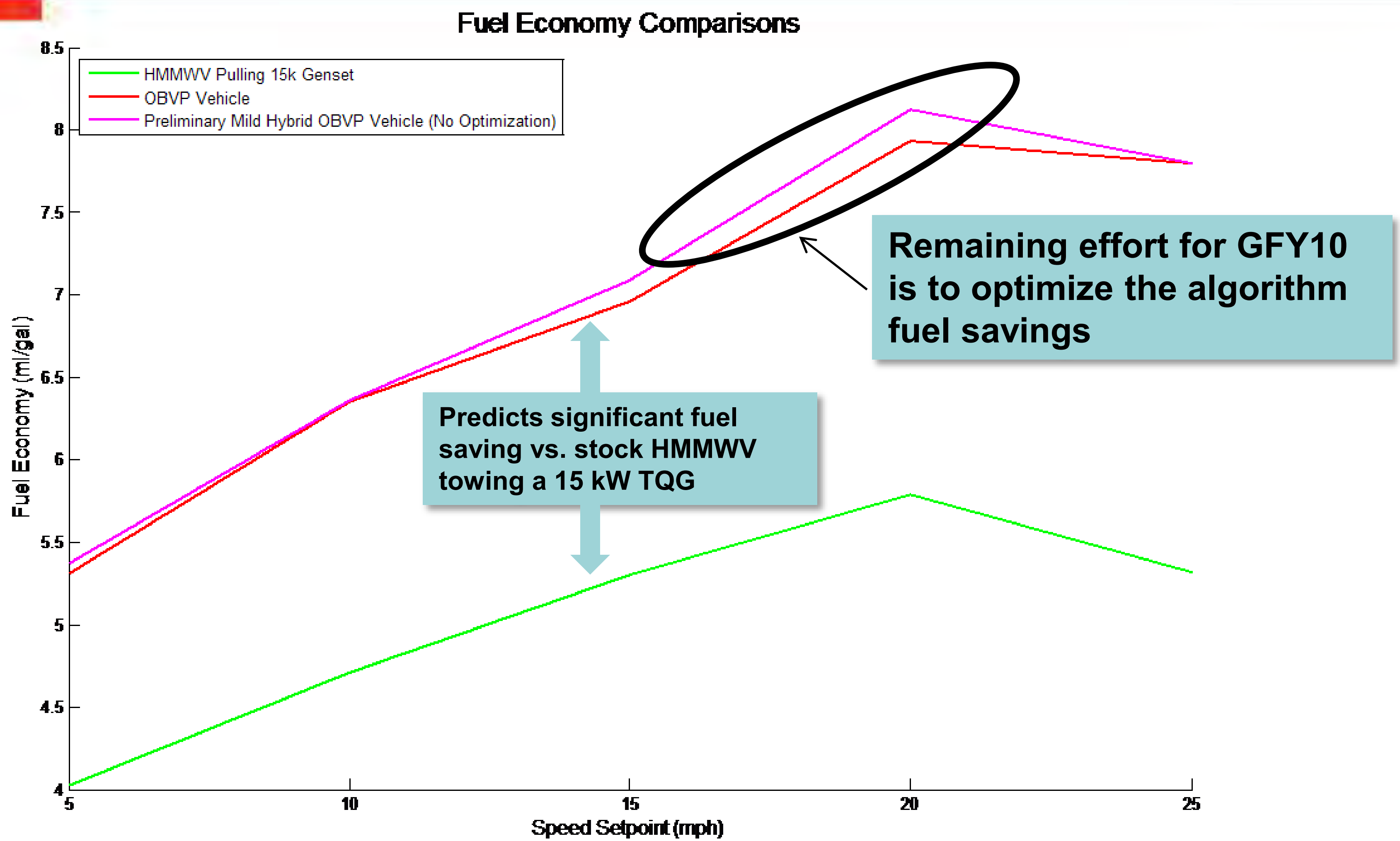
Mild hybrid algorithm must optimize control of torque for best performance

Engine Optimization Strategy



Speed does not significantly affect efficiency, the hybrid algorithm needs to monitor torque. The "rule based algorithm" will use the optimization graph to identify the 3 regions of operation as shown

First Non-Optimized VPSET Results



GFY 2011 and 2012 Future Plans

GFY 11 Plans

- Complete baseline vehicle testing
- Add idle engine speed control based on power demand capability (Stationary mode)
- Code simulation algorithms in control DSP inside of GSC
- Utilize SIL to evaluate baseline algorithms
- Evaluate simulated vs. “real world” performance of simulated algorithms in SIL and truck
- Update models based on testing/actual data

GFY 12 Plans

- Acquire hardware/integrate to truck (GSC, batteries, throttle control, etc.)

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2011 Joint Service Power Expo

Office of Naval Research
Maneuver Science and Technology Programs in Fuel Efficiency and Battlefield Power

Michael Mimnagh

Maneuver Thrust Area

Expeditionary Maneuver Warfare and

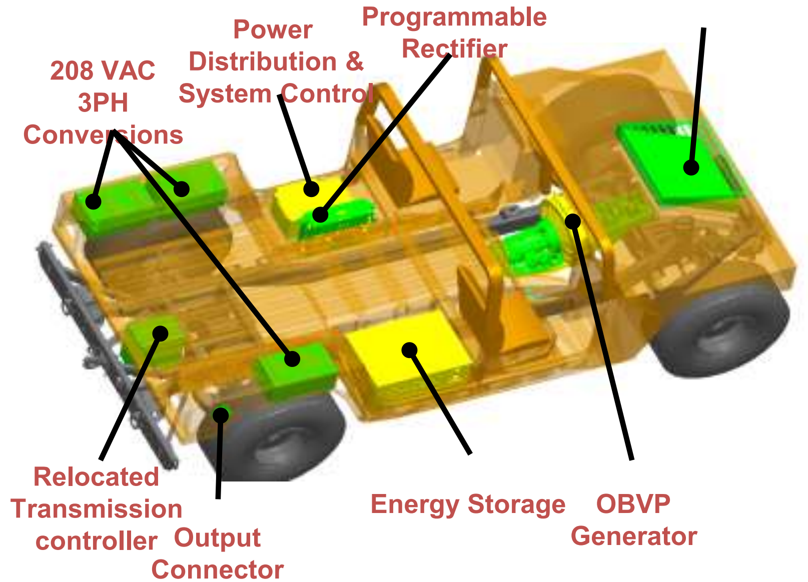
Combating Terrorism Dept (Code 30)

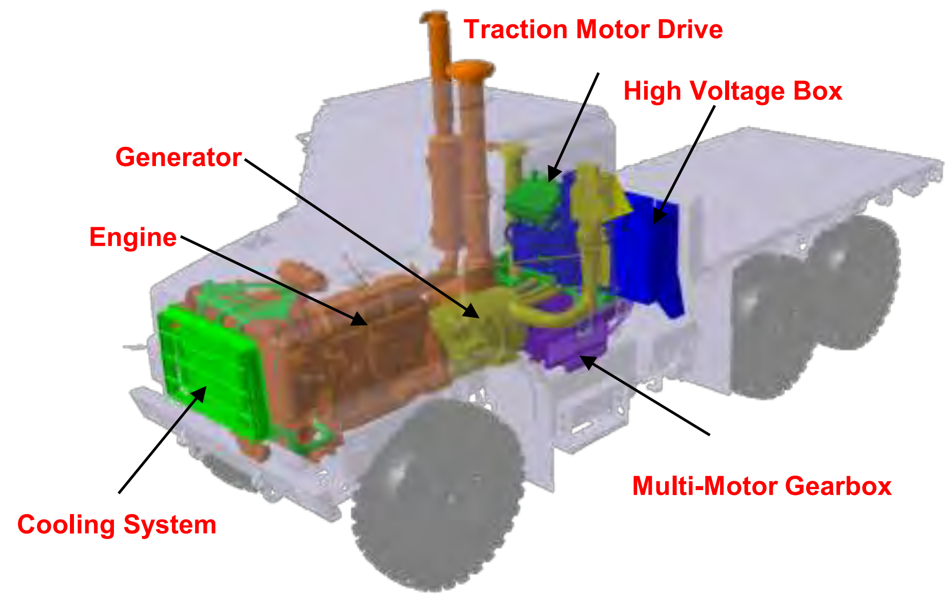
Office of Naval Research

- Exportable Power Program Overview
- Transmission Integral Motor/Generator
  - HMMWV On-Board Vehicle Power System (OBVP) Overview
  - 3000 Series Transmission Integral Generator (“3TIG”)
  - Electric Torque Assist
- Medium Tactical Vehicle Replacement (MTVR) OBVP
- MTVR “Hybrid” OBVP
- Medium Electromechanical Infinitely Variable Transmission
- Summary & Link to ONR Long Range BAA

Exportable Power Program Overview

- DRS HMMWV
  - PM Generator Integrated Into HMMWV Mechanical Transmission
  - Power Electronics Converter For Fixed Frequency (60 Hz) Export And Mobile Power Over Range Of Engine Speed
  - 30kW Of Static Exportable Power, 35kW Of Static Power Surge, 10.5kw Of Mobile Power
- Oshkosh MTVR
  - Implements ProPulse Electric Propulsion System
  - 280 kW Generator, Configurable For 208/480 VAC
  - 120kW Static Exportable Power, 21 kW Of Mobile Power





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HMMWV On-Board Vehicle Power System Overview

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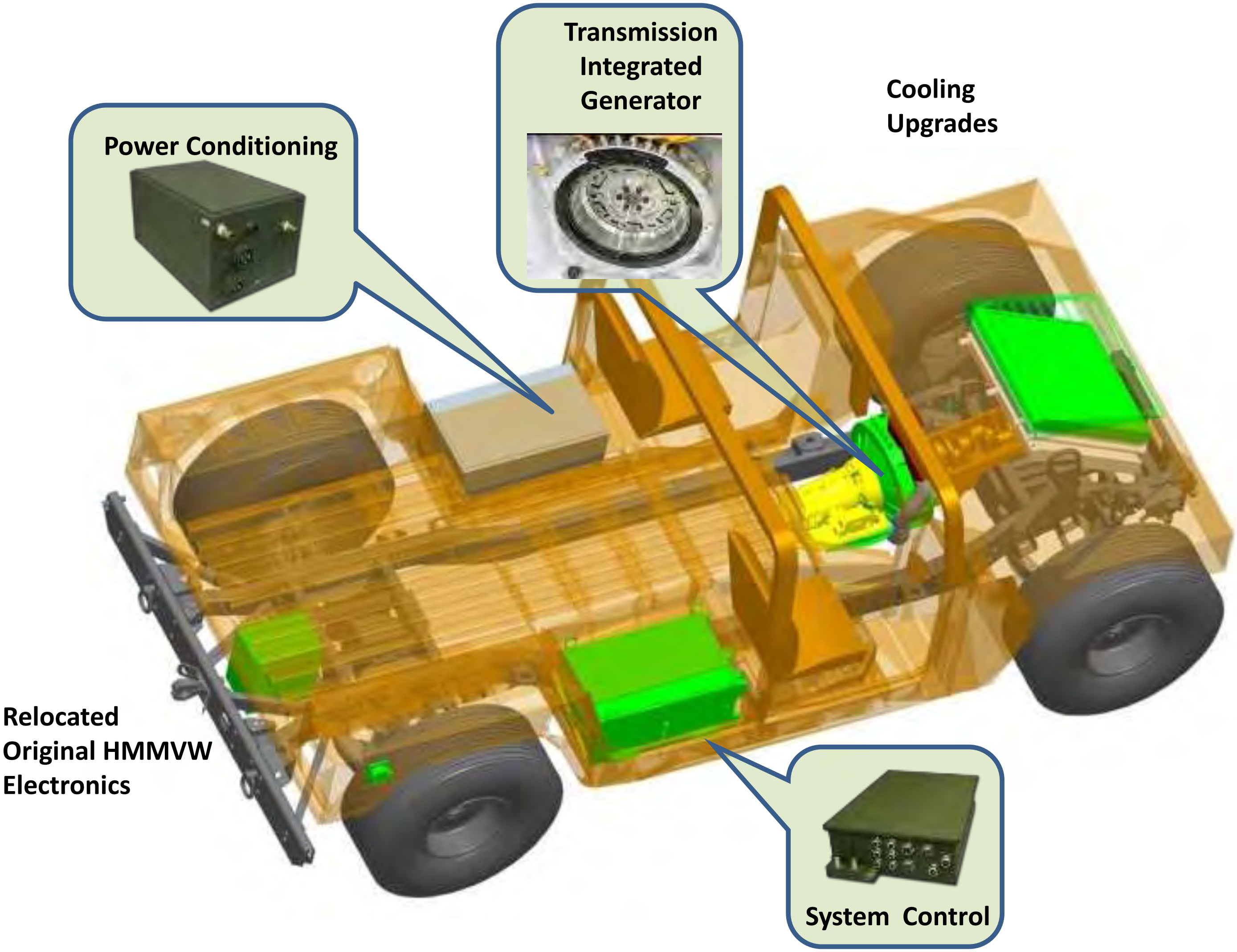

- Transmission Integral Generator (TIG) exportable power approach
- Up to 30kW stationary exportable power
- 10 kW mobile exportable power
- Retrofit “Kit” Approach

HMMWV On-Board Vehicle Power Logistics Savings

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Existing Configuration to Deliver 30 kW with HMMWV Class Vehicle

HMMWVs

+

15 Kilowatt Generators

+

Soldiers

= 30 kW

USMC OBVP Equipped HMMWV Configuration to Deliver 30 kW

HMMWV OBVP

+

Soldier

= 30 kW

- Weight Reduction
- Volume Reduction
- Manning Reduction

Significant logistics savings achieved using HMMWV OBVP

Office of Naval Research

Scalability of Transmission Integral Generator Concept

National Defense Industrial Association

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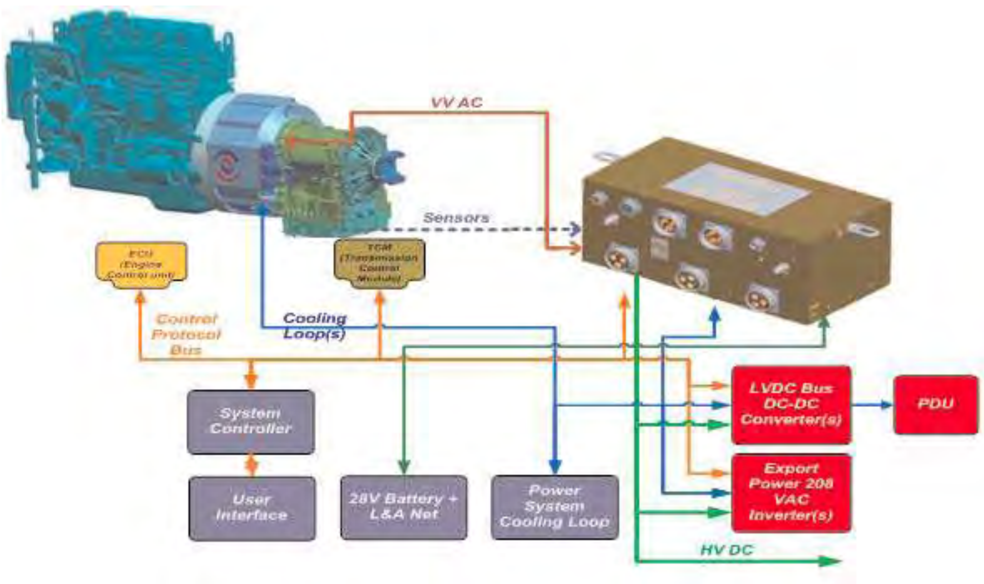
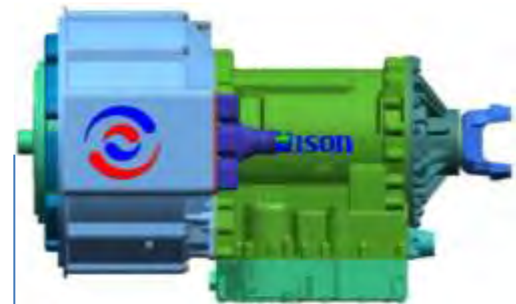




3200TIG Transmission

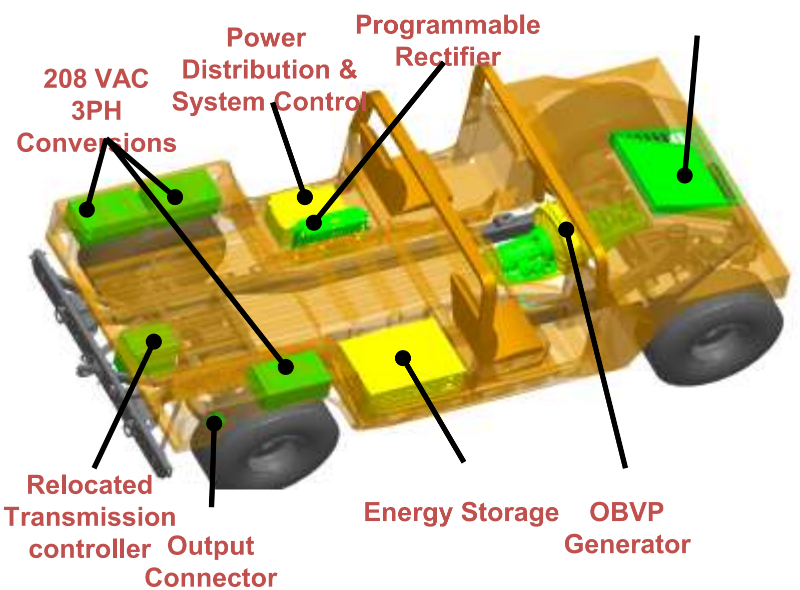
3200SP Transmission

No Impact to Drive Line Space Claim

- **Installs at factory or depot using standard tools and mounts**
- **More than 125 kW of continuous electric power while stationary**
- **No impact to the vehicle driveline**
- **High voltage output available (300 VDC to 600 VDC)**
- **120/208 VAC at 50/60 Hz**

Exportable Power System Components Leveraged for Vehicle Fuel Efficiency Gain

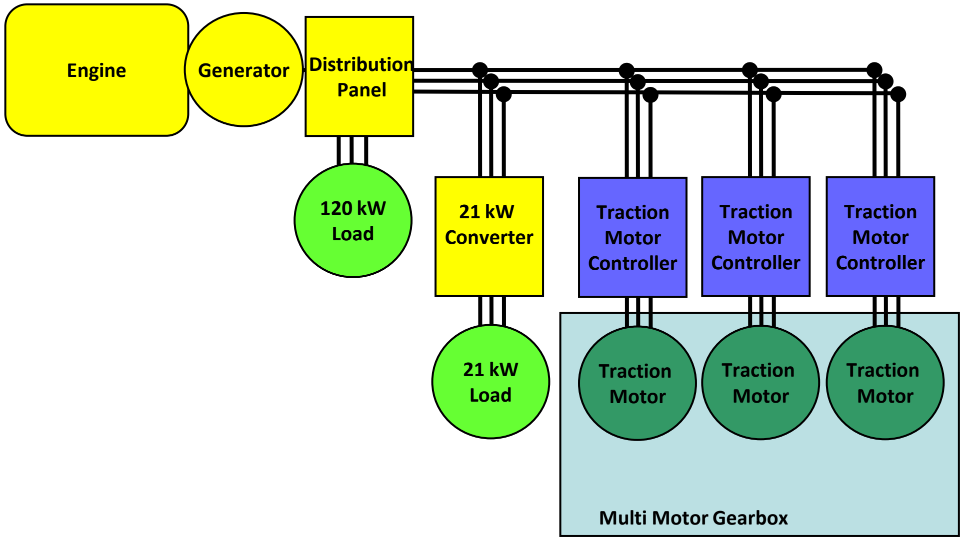
- Electric Assist Components
  - Base HMMWV OBVP Kit
  - Accelerator Pedal and Other Sensors
  - **Motor/Generator Controller** (bi-directional power converter)
  - Battery System
  - Hybrid Electric Vehicle Controller



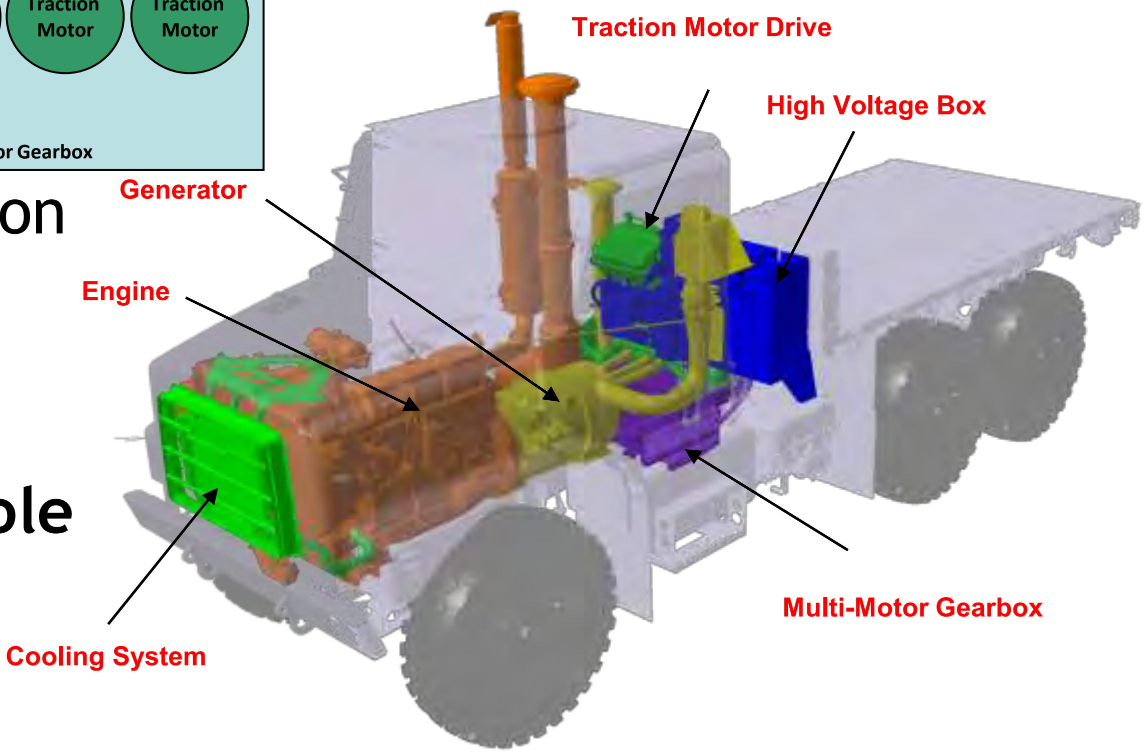
- Load Split Algorithm
  - System uses the **electric machine as generator** to charge the battery when drive system is operating at high efficiency
  - System uses the battery and **electric machine as motor** to assist when drive system is operating at low efficiency
- Additional Efficiency Through Regenerative Braking
- Improve Efficiency of Exportable Power Transient Performance

Approach Applicable for other Transmission Integral Motor/Generator Systems

Oshkosh MTVR OBVP System Overview



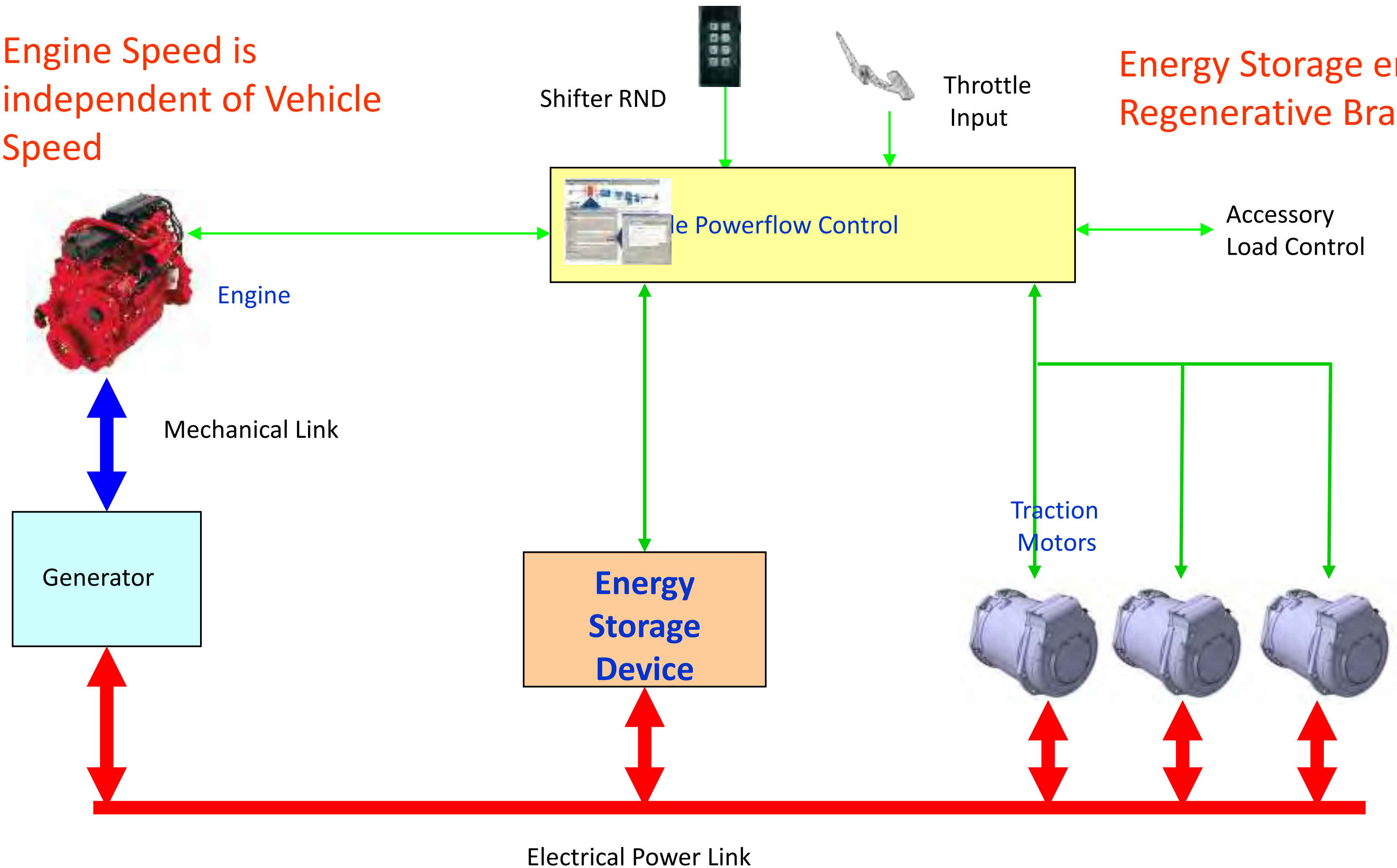
- Diesel electric Propulsion
- 120kW stationary exportable power
- 20kW mobile exportable power



Oshkosh MTVR Hybrid-OBVP High Level Control Schematic

Engine Speed is independent of Vehicle Speed

Energy Storage enables Regenerative Braking



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Oshkosh MTVR Hybrid-OBVP

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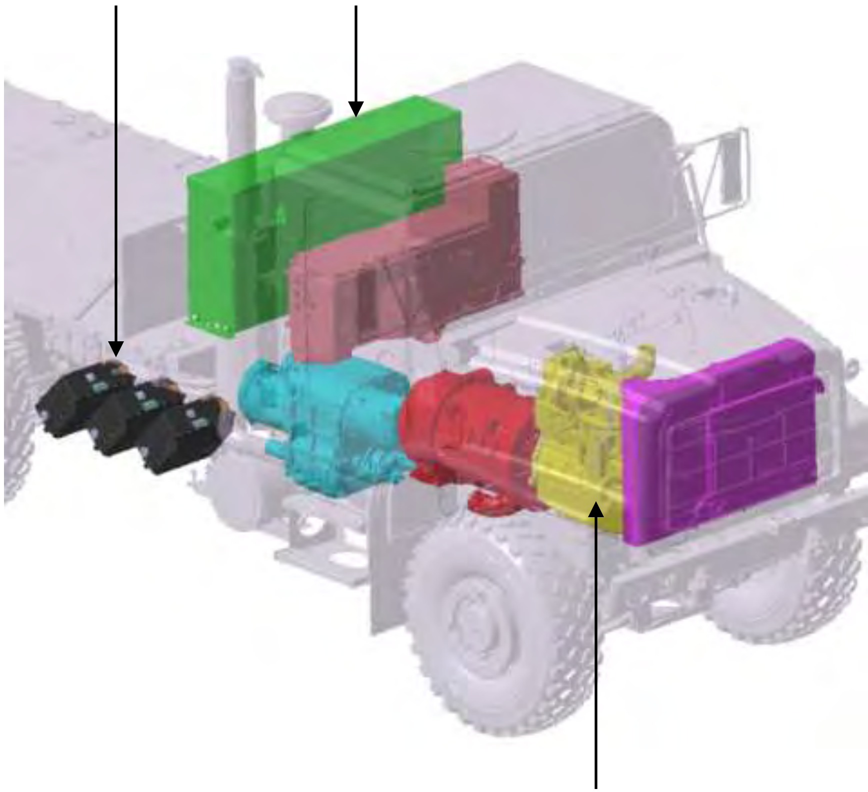
- **Technical Approach**
  - Build on MTVR OBVP ProPulse® Drive System, capitalizing on continuously variable nature of series electric drive through the addition of regenerative braking and selecting a power dense (vs. torque dense) engine.
  - **"Hybridize"** with Regenerative Braking Subsystem
  - Capacitor based energy storage modules
  - Develop charge/discharge control algorithms to optimize regenerative braking
  - **"Repower"** with power dense engine
  - Continuously variable nature of series electric drive allows prime mover to make requisite mobility power at any optimum efficiency speed
  - No low end torque requirement allows lighter weight options.
  - Decrease in engine weight achievable

Hybridize with Energy Storage and ProPulse® Drive System



Repower with power dense engine

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Oshkosh Electromechanical Infinitely Variable Transmission

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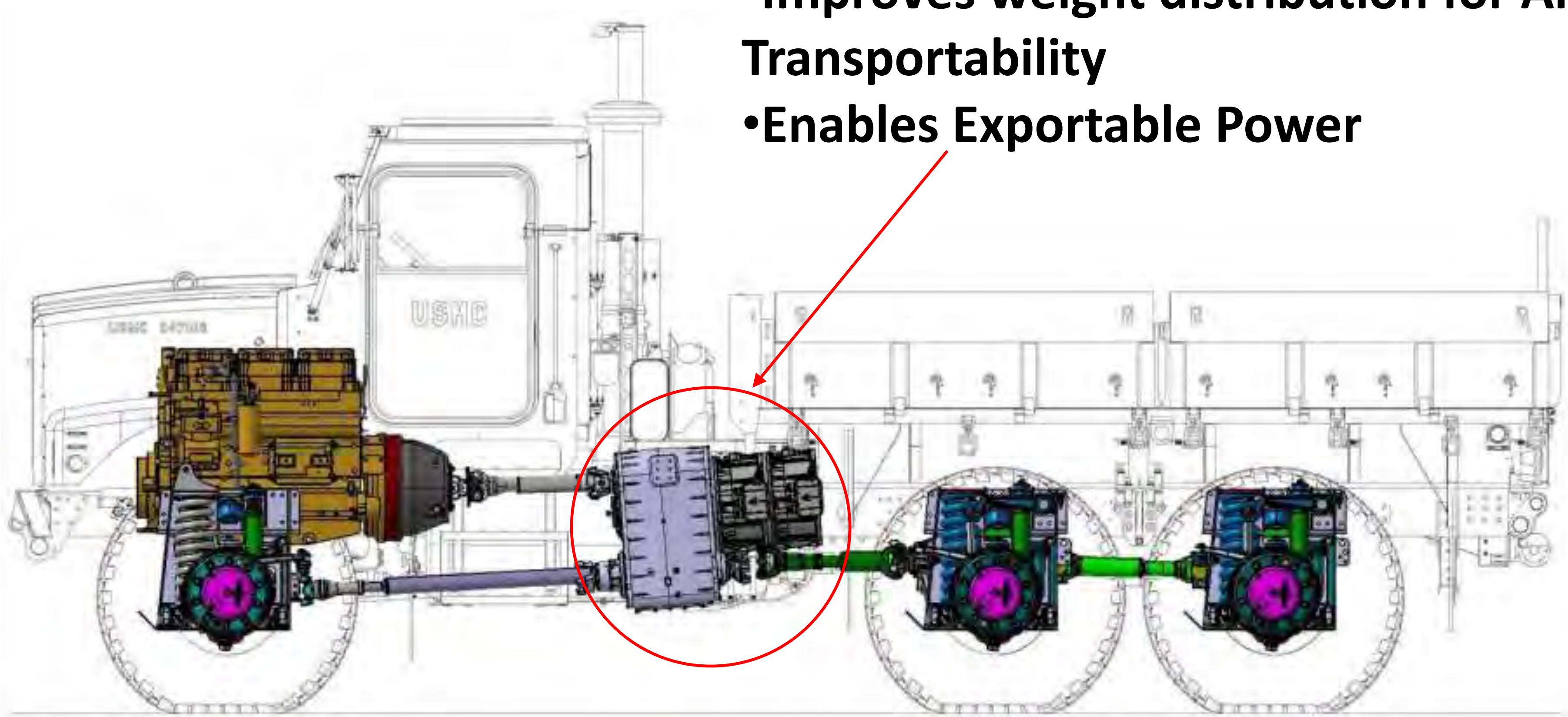
- Alternative powertrain for medium vehicles
- Transfers weight from front axle
- Improves weight distribution for Air Transportability
- Enables Exportable Power



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Oshkosh EMIVT Control Schematic

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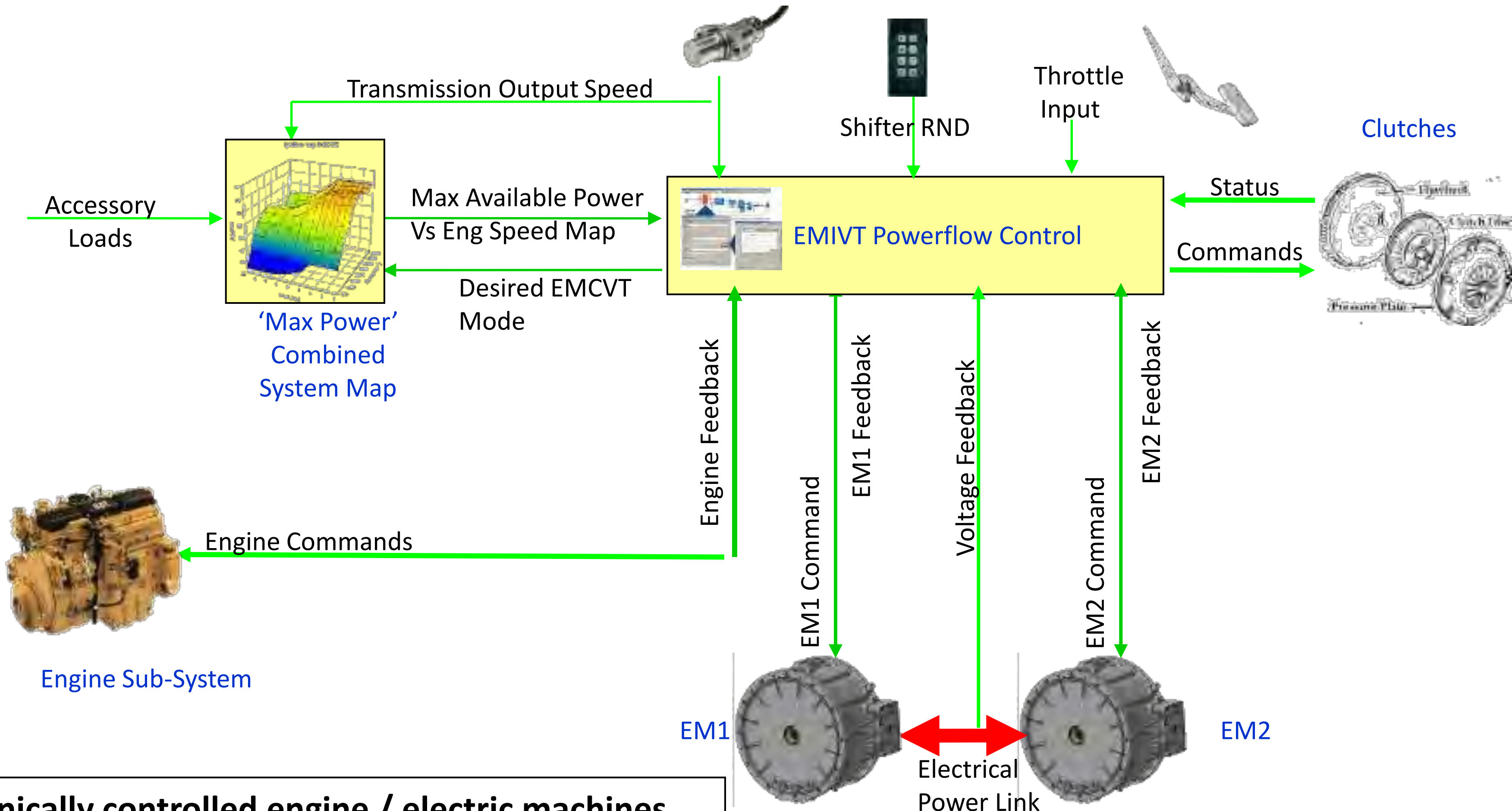
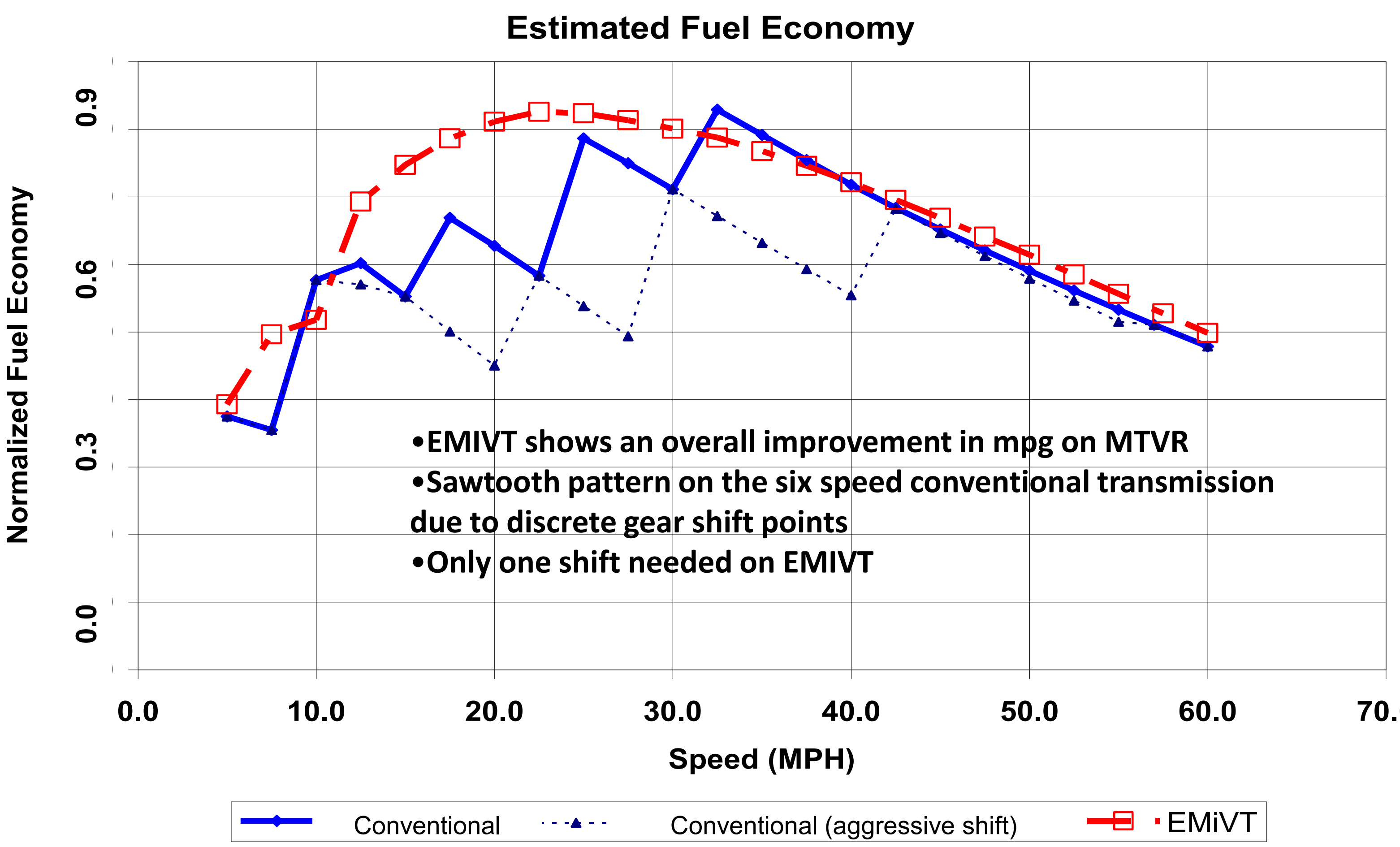
System Controlled to Minimize Combined System Losses



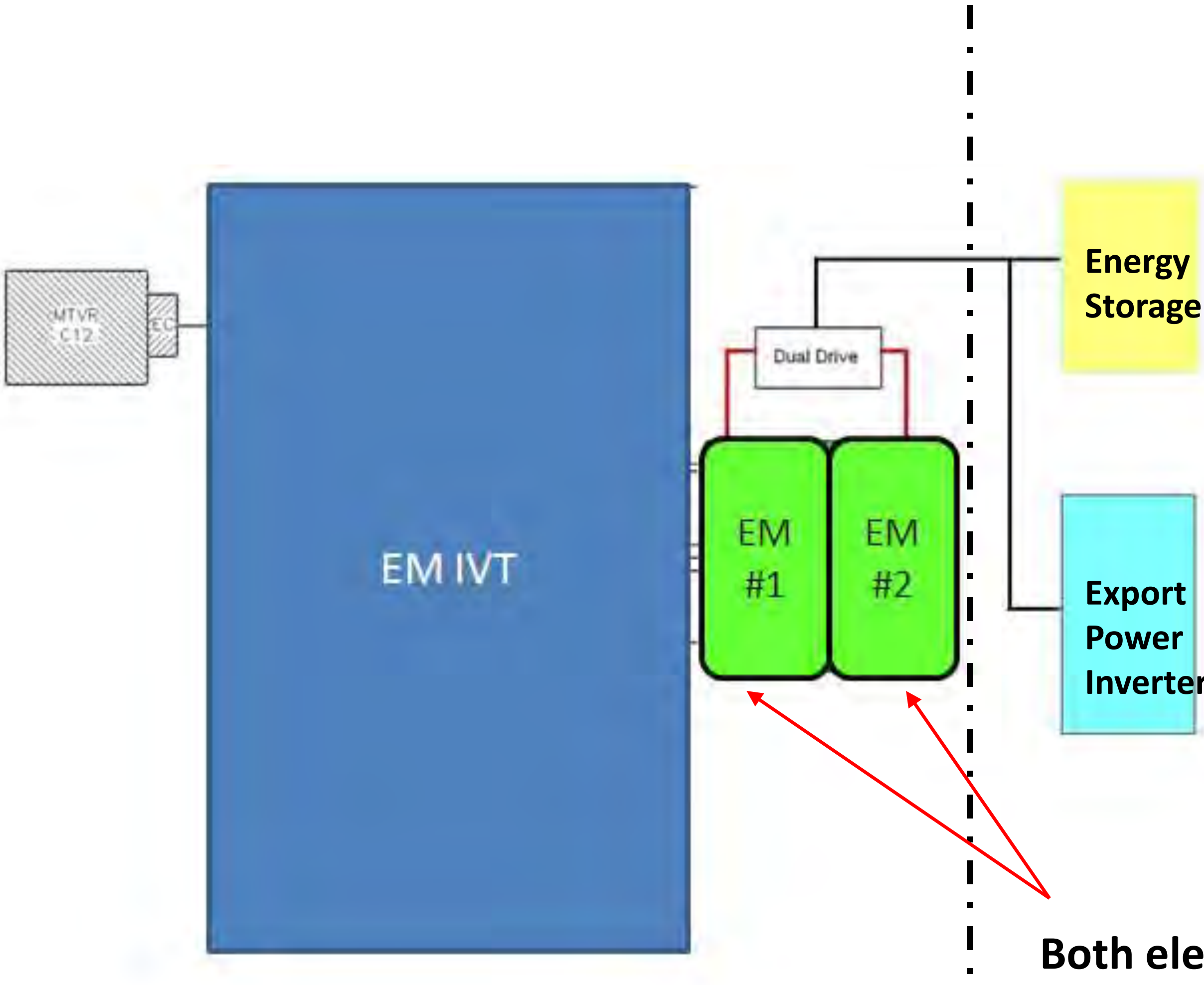
- **Electronically controlled engine / electric machines**
- **System architecture yields efficient, redundant operation**
- **Power management algorithms optimize efficiency**

Oshkosh EMIVT Fuel Economy Simulation

- Preliminary comparison between **conventional powertrain and and EMIVT**
- Simulation of **cruising** “steady state, flat road” operation - **no energy storage**
- Addition of **energy storage** can further improve mpg by **10-15% depending on drive cycle**



Oshkosh EMIVT Control Schematic



Future Options

- Regenerative Braking with the addition of Energy Storage option for Improved Fuel Economy

- Export Power capability with addition of DC to AC inverter
- 150kW stationary power
- 30kW mobile power

Both electromagnetic machines may be operated as generators

ONR Fuel Efficiency and Battlefield Power Program Summary

- Marine Corps Expeditionary Energy Strategy
  - **"By 2025… the only liquid fuel needed (by Marine Expeditionary Forces) will be for mobility systems, which will be more energy efficient than systems are today."**
  - *Mobility systems will also provide exportable power for battlefield needs.*
- Integration of electromechanical power systems (generation, storage, conversion, and control) with vehicle drive systems enables fuel efficient mobility and exportable power.
  - Series Electric Drive – High Power Applications
  - Transmission Integral Motor/Generators – Small/Medium Applications
  - EM IVT – Alternative Mobility/Exportable Power System
  - ***Future Capability Enabler – Directed Energy, Energy Based Survivability***
- Other Applicable Approaches
  - Fuel Cells, Auxiliary Power Units
- Science and Technology Needs – High Temp, Power Dense Components
- **COST - Acquisition Cost as Important as Lifecycle Cost Savings**
- ONR Long Range BAA
  - **http://www.onr.navy.mil/en/Contracts-Grants/Funding-Opportunities/Broad-Agency-Announcements.aspx**

SCRA

Advancing Renewable Energy Technology Commercialization

through

Federal, State and Local Collaborations

Russ Keller
Vice President, ATI
3 May 2011

Who We Are

SCRA …

- Is a non-stock, tax-exempt **applied research and commercialization services company** with more than 25 years of experience building multi-organizational teams.

- Currently **manages more than 100 national and international programs worth over $1B** in applied R&D contract value.

What We Do

SCRA…

- **Leads applied research and commercialization** across a diverse range of industries
- Facilitates **technology solutions** with broad-industry involvement and impact
- Provides **commercialization services** for rapid, industry-wide technology implementation
- **Creates custom collaborations** with leaders from industry, government, and academia
- Executes **objective leadership** in an environment of trust where competitors collaborate for mutual benefit

What We *ALSO* Do

SCRA…

- **Manage three research parks** in the state of South Carolina (Charleston, Columbia, Clemson)
- **Execute economic development mandates from the South Carolina General Assembly**
  - **Construct, staff and manage three Innovation Centers** within the state
  - Work with the state's three research universities to **accelerate commercialization of university-generated Intellectual Property**
  - **Provide support services for "knowledge economy" business formation and growth…including seed venture capital investments**

A Unique Combination….

- **State Economic Development Mission** *and*
- **Technology Solutions and Services Focus** *supported by*
- **Infrastructure for Innovation**

….where the whole is greater than the sum of the parts.

Overview

- **The Power and Energy Challenge**
  - Mission requirements; capability needs
  - Executive Order 13514 direction
  - DoD and Service-specific vision / guidance
  - Budgetary constraints
- **Potential Solution Set**
  - Buy “off the shelf”
  - Develop internally (ONR, ARL, AFRL, UARCs, etc.)
  - Develop externally
    - “One off” contract to meet specific need
    - Long term contract to meet this and future related needs
- **Proposed Solution – Go to market…..without having to go it alone**
  - Successful case studies
  - Emerging opportunities

A Challenging Landscape

- **E.O. 13514 (October 2009)**
  - Reduce energy intensity in buildings
  - Increase use of renewable energy; implement renewable energy generation projects
  - Reduce use of fossil fuels
  - Reduce GHG emissions
- **DoD / Service-specific vision/guidance (Navy as example)**
  - October 2010 “Navy Energy Vision”
    - By 2020, half of total Navy energy consumption afloat from renewables
    - Sail the “Great Green Fleet” by 2016 (nuclear, hybrid-electric ships running on biofuel, aircraft flying on biofuel)
    - By 2020, half of Navy’s total energy consumption ashore from alternative sources
    - By 2020, half of Navy installations “net-zero” energy consumers
- **Budgetary constraints**
  - Deficit reduction pressure
  - Competing Service budget priorities (recapitalization, maintenance and repair, etc.)
  - DoD acquisition efficiency improvement initiatives

Potential Solution Set

- **Buy commercially-available (COTS)**
  - Must accommodate military-unique requirements / operating environment
- **Develop internally (DoD labs or University Affiliated Research Centers)**
  - Many, but not all skill sets are available “in house”
  - Cost effectiveness jeopardized if unique new infrastructure required
  - **There is no dedicated UARC for power and energy technologies**
- **Develop externally (“traditional” contract with outside providers)**
  - May or may not need to fund new infrastructure
  - Government’s overhead challenge grows with multiple, “one-off” contract transactions
  - Breadth of capability challenge grows with long term contract to single provider having deep but narrowly-focused skill sets
- **Develop jointly with others**
  - Other services
  - Other federal agencies
  - Non-federal entities (including consortia of private industry / academia entities)

Potential Solution Set

Increasingly, the answer seems to be….

OPP / OPM

(Other People's People; Other People's Money)

Given the significant overlap of power and energy requirements, objectives and research assets across Services, federal agencies and the private sector, the opportunities for mutually-beneficial collaborations are significant

- Affords advantages of shared infrastructure, shared awareness, multiple opportunities for technology transition
- This approach is consistent with current DoD efficiency initiatives

However,

- No "silver bullet" template for every case, but worth evaluating the extra effort required for multi-party collaboration versus the potential payoff if successful
- Even if the will to collaborate is there and the potential payoff is evident, some degree of herding cats is going to be required

Initial Considerations

- Does the "pain" exist in more than one Service or agency?
  - **Is there interest by more than one "customer?"**
- Does the solution require university or other research assets (people and/or facilities)?
  - **Who needs to be part of developing the solution?**
- Does the "pain" extend to the private sector?
  - **Is there a shared interest in the private sector for finding a solution?**
- Does geography matter?
  - **Are there federal, state or local incentives that can reduce the cost of developing the solution?**

Federal Landscape

- **Potential “Customers” for Power and Energy Solutions**
  - DoE
  - DoD
  - DHS
  - USDA
  - DoT (FTA)
  - EPA
  - DoC (Economic Development Agency)
- **Financial Incentives for Renewable Energy**
  - Investment Tax Credits
  - Internal Revenue Code / Treasury Regulations for non-profit organizations

State Landscape

- **Varies by State**

- **South Carolina has several legislative initiatives very supportive of renewable energy technology in general, and hydrogen and fuel cell technology in particular**
  - Research Centers of Economic Excellence Act (2002)
  - Research Innovation Centers Act (2005)
  - Industry Partnership Act (2006)
  - Hydrogen Infrastructure Development Act (2007)

- **Fuel Cells 2000 "State of the States" report (Spring 2010) listed South Carolina as one of the top 5 states in the US in advancing hydrogen and fuel cell development**
  - Others were CA, OH, CT and NY
  - SC cited specifically for "promoting demonstrations, hydrogen stations and business development"

Collaboration Case Studies

- "Traditional" model is a Federal Agency - Industry (or Academia) partnership
  - Agency solicits solutions to meet requirements
  - Industry (academia) develops solutions
  - Agency provides funding (may require cost share)

HOWEVER…

- Other models exist and may help advance technology and/or share funding burden and/or accelerate commercialization opportunities
  - Federal -- state -- local -- industry
  - Federal inter-agency -- state -- industry
  - Federal inter-agency -- regional – industry
  - Private industry -- federal -- state
  - Others

SCRA Novel Technology R&D Partnerships

- **Model: Federal -- state -- local -- industry**
- Example: National Fuel Cell Bus Program
  - Federally-funded; cost share requirement of 50%
  - Customer: FTA
  - Partners
    - CTE (Atlanta-based non-profit)
    - Proterra (bus manufacturer)
    - University of South Carolina (demonstration site coordinator)
    - Central Midlands Regional Transit Authority (demonstration site operator)
    - SCRA (fueling infrastructure coordination)

SCRA

Proterra Bus Preparing to Fuel at Columbia Hydrogen Fueling Station, March 2009

SCRA Novel Technology R&D Partnerships

- **Model: Federal inter-agency -- state -- industry**

- Example: Fuel Cell Backup Power "Market Transformation" project at Ft. Jackson, SC
  - Federal / state co-funded
    - DoE $325K; SCRA $155K
  - Inter-agency agreement between DoE and DoD
    - Administered through Army Corps of Engineers Engineer Research and Development Center (Construction Engineering Research Laboratory)
    - Executed by ATI
  - Agreements structured to enable private partner (Logan Energy) the ability to capture federal investment tax credit for fuel cell equipment

SCRA

Fuel Cell System Backup for Ft. Jackson Emergency Services Center, April 2009

Novel Technology R&D Partnerships

- **Model: Federal inter-agency -- regional -- industry**
- Example: Ft. Sumter Renewable Energy Project
  - Co-funded by two federal agencies (DoE, National Park Service)
    - Follow-on phases will leverage funding from state/local entities
  - Marries DoE H&FC "Market Transformation" program (focused on hydrogen/fuel cell technology) with NPS "Smart Parks" initiative (focused in this case on solar technology)
    - Administered through Army Corps of Engineers Engineer Research and Development Center (Construction Engineering Research Laboratory)
    - Project will be the first under DoE-NPS Smart Parks Initiative
    - Regional economic development group (Aiken, SC) partnered on the project and is contributing cost share
    - Executed by ATI

Planned Site for Ft. Sumter Renewable Energy Project, Fall 2010

SCRA Novel Technology R&D Partnerships

- **Model: Federal -- state -- private industry**

- Example: Landfill Gas – to – Hydrogen Production for Use in Industrial Material Handling Fleet

  - Host site: BMW Manufacturing Company (Greer, SC)
  - Funding sources:
    - US Department of Energy
    - SC Energy Office
    - SCRA (via SC Industry Partnership Fund, Hydrogen Infrastructure Development Fund)
    - Private foundation(s)
  - Project goals
    - Prove economic and technical feasibility of converting LFG to hydrogen
    - Demonstrate no adverse impact on long term fuel cell MHE performance using LFG-produced hydrogen
    - Support BMW decision to scale up to support entire MHE fleet (>400 pieces)

SCRA

BMW X5 and X3 Production Facility, Greer, SC

Metrics of Success

Innovator Award for:

- outstanding initiative that encourages economic opportunities and quality of life relating to bio-products, alternative energy, and energy efficiency
- innovative use of technologies to promote energy efficiency; promotion of cross-industry collaboration; commercialization/technology transfer; preparation of workers for green collar jobs; and its replicability to other organizations or geographic areas
- collaborative partnership with the public, private, university, government and nonprofit sectors

Gov. Haley Barbour Presents Southern Growth Policies Board "Innovator Award" to SCRA CEO Bill Mahoney, June 2009

Wrap-Up

- **Ingredients for success:**
  - Supportive legislation (federal and state)
    - Sometimes geography matters a lot
  - Supportive regional / local communities
    - Often associated with research universities / institutions
  - Address the most pressing source of customer “pain”
    - Varies by geography and by target market
  - Collaboration and cooperation
    - Shared risks and rewards to create market demand (and market acceptance)

- **Hard realities:**
  - Federal funding availability (and priorities) can be unpredictable
  - State economic development construct biased against small, entrepreneurial companies (immediate job creation)
  - Competing technologies (including incumbent technologies)
  - Public perceptions (and mis-perceptions)

Questions?

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The Future Funding of Development Efforts on Power Technologies

Moderator: Glen Bowling

The information provided herein is the opinion of the author and is neither endorsed nor denied by the J.S.P.E. or any Govt. employee or participant.

How it has been

- Modest levels of funding from DOD budget
  - > Competitive awards
  - > BAA awards
- Earmarks for Specific Topics
  - > Normally clear who wins
  - > Normally the R&D effort is company derived
  - > Most are BAA awards

What Has Changed

- Earmarks are dead in the House
- Earmarks are mortally wounded in the Senate
- Committee resolution will most likely not include many, if any Earmarks

- It may only last 2 years
- It may become permanent (doubtful)
- They may change the rules to force all Earmarks to be competitively awarded in DOD

How do we do R&D in the future?

- Govt Employees
  - > Apply for funding every way possible
  - > Use special programs like MANTECH, Foreign Competitive Technology
  - > Hold open meetings to discuss with Industry what areas need to be funded
  - > Hold Industry Day and present your plans in tangible terms
    - Tell us the programs you intend to fund
    - Tell us the scale of the program and funds you have
    - Tell us the schedule
  - > Use BAA or Competitive Bid or….

What can Industry do?

- Participate! Attend the aforementioned meetings
- Lobby your Congressional Delegation to support the DOD Budget (sounds dumb, but in the current environment, it is necessary)
- Be competitive – Bid to win
- Be communicative if possible. Can't share your secrets but you can speak up if something is needed

The way forward

- Encourage the NDIA Power Forum to push for more unrestricted (i.e. not SBIR) R&D funding for Power Sources
- All Contractors engage our Congressional Delegation to make the aware of our need to be supported in R&D to make the Warfighter better off
- All Government Employees get aggressive with funding requests and methods of creating and funding programs within the system

We are in this together!

Discussion

- General Comments?
- Disagreement?
- Ideas on successful programs other than standard?
- Cooperative R&D with friendly nations?
- How can we help each other better in this environment?

PETALUMA GREEN

USCG Training Center Petaluma
Energy & Water Conservation and Natural Resources Protection

Joint Service Power Expo

U.S. Coast Guard
May 2011

Solar Photovoltaic
Power Purchase Agreement

- 875 kW photovoltaic array
- Contractor financed, built, operated and maintained
- 5232 panels on 4 acres
- USCG purchases power at contracted rate for 25 years
- Helps meet EPACT 2005 requirements for USCG

Solar Photovoltaic
Power Purchase Agreement

- Construction completed Oct 2009
- Grid-tied into 12.47 kV distribution system
- Estimated $1.7M energy savings over life of project
- Over 1,910,000 kWh produced since March 2010
- Reduction of over 2,400,000 lbs of CO_2 greenhouse gas per year

Solar Photovoltaic
Bauer North Array

- 45 kW Array
- Non-penetrating mounting
- Seismic Zone 4
- Installed Dec 2003
- 135 mph wind tested
- Fixed 5 degree tilt
- Has produced over 775,000 kWh to date.

Solar Photovoltaic
Bauer South Array

- 35 kW Array
- Non-Penetrating Mounting
- 135 mph wind tested
- Seismic Zone 4
- Installed Dec 2003
- Fixed 5 degree tilt

Solar Photovoltaic
Horsley Hall East Array

- 45 kW Array total
- Rail Mounting
- Installed Dec 2003
- Fixed 22 degree tilt
- Has produced 495,000 kWh to date

Solar Photovoltaic
Petaluma Rooftop Solar Arrays

- Grid-tied into building main distribution panels
- Partially funded with 50% solar initiative incentive.
- 125 kW combined arrays have produced over 1,270,000 kWh to date
- Also avoided nearly 1,700,000 lb. in CO_2 greenhouse gas to date

Solar Energy
Swimming Pool Solar Pre-Heat

- Passive ground mounted solar hot water system
- Pre-heats swimming pool water
- Heats to desired temp and automatically shuts off
- Completed July 2009

Solar Energy
Swimming Pool Solar Pre-Heat

- 72 panels @ 48 s.f. arranged in 9 arrays totaling 3456 s.f. of collector.
- Two 2hp pumps circulate water through system.
- Saves $12-17K per year in propane costs for heating.
- 8-12 year payback.

Solar Photovoltaic
Solar School Gate

- Remote controlled PV powered school gate and streetlight

- Avoided significant costs for trenching, conduits and wiring to a remote location

Solar Photovoltaic
Solar Seismic Station

- Solar powered seismic monitoring station

- Avoided significant costs for trenching, conduits and wiring to a remote location

Solar Energy
Solar Streetlights



- Energy savings
- Low installation costs
- Excellent for remote areas
- Substantial savings in avoided costs for trenching, conduits and wiring.
- Converting from HID to LED

Solar Energy
Harrison Hall Solar Thermal Refurbishment

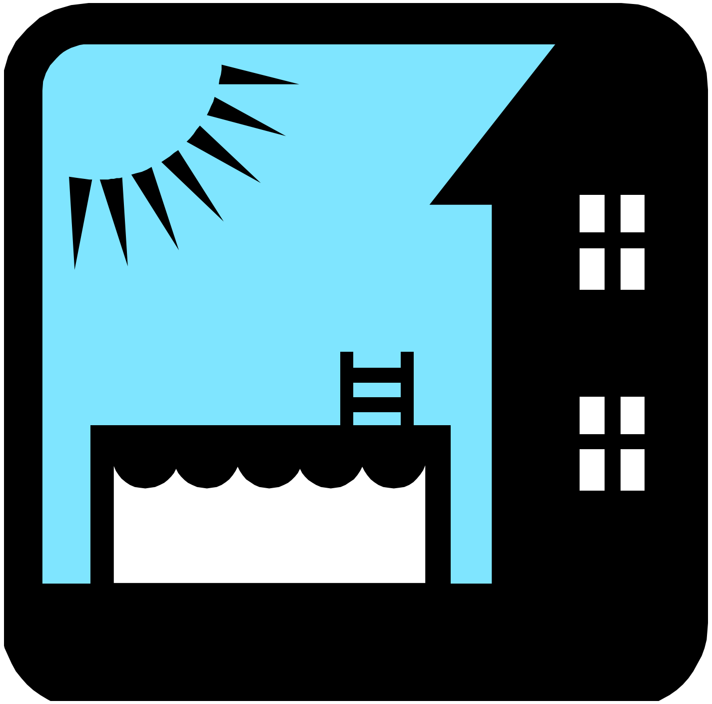
- Solar hot water system used as water pre-heat for the building boilers.
- Originally installed in 1985. Reconditioning scheduled for FY-11
- Refurbishment will alter piping to expand and incorporate space heating.

Solar Energy
Harrison Hall Boiler Solar Pre-heat

- Estimated savings of $7-12K per year in propane costs for heating.
- Offsets 3,300 therms of domestic hot water heating annually.
- Incorporation of space heating will increase that to 4,500 therms
- 3-4 year payback

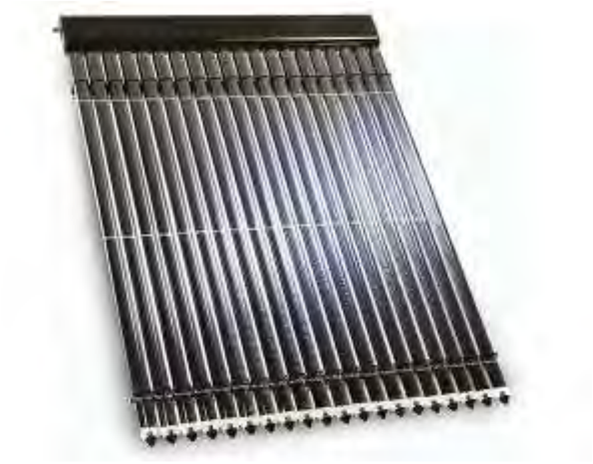
Other Solar Energy Initiatives
Solar Thermal for Domestic Hot Water

- Assessing solar thermal domestic hot water systems for two barracks
- Facilities similar to 84 and 114 room hotels.
- 60%-80% savings can be achieved in some systems
- Possible combined savings of $18K/yr.
- 15-20 year payback without incentives



Other Power Initiatives in Planning

- Solar Hot Water Systems for Housing



- NEPA underway on Meteorological Tower

Questions?

Ascent SOLAR

Ascent Solar Technologies

2011 Joint Service Power Expo

R&D 2010 100

Company Snapshot

R&D Magazine Selected Ascent as one of the 100 Most Innovative Technologies in 2010

- **Founded:** **2005 (technology development started at ITN Energy Systems in early 1990's)**
- **IPO:** **July 2006**
- **Headquarters:** **Thornton, CO**
- **Manufacturing:** **Colorado**
- **Technology:** **Thin-Film CIGS (flexible, plastic substrate)**
- **Manufacturing Process:** **Roll-to-roll manufacturing, monolithic integration, intelligent process control**
- **Status:** **Commercially producing modules**
- **End Markets:** **Defense, Consumer, Transportation, Aerial, Off-Grid and BIPV/BAPV**

Defense: Cost of Fuel

Solar has the potential to become a significant source of fuel savings

"Towards Developing Fully Burdened Costs" - Headquarters USMC
Edward Blankenship, PA&E
Randal Cole, Ph.D., CNA

Up to $1-billion in annual savings assuming average cost $50-gal

Fully Burdened Cost Of Fuel

The Fully Burdened Cost of Fuel is defined as the cost of the fuel itself plus the apportioned cost of all of the fuel delivery logistics and related force protection required for delivery

Cost to Deliver Fuel to Forward Bases

Convoy with Security	$9.20 - $11.81/gal
Convoy with Air Security	$15.63 - $18.59/gal
Air Drop	$28.94 - $30.78/gal
Air Drop with Security	Up to $400/gal

Fuel Savings from Solar

Total Number of Gallons Consumed = 357-M
DoD reports that 5% solar adoption could save 17.8-M gallons of fuel

The Current Problem

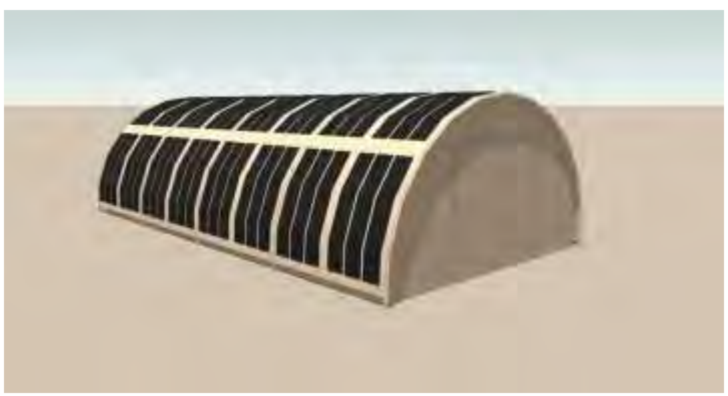
- We're spending $12B per year in fuel for cbt sys*
- FOB "X" in Afghanistan
  - 53 wired generators
  - Less than 20% efficient
  - Total cap. 10 MB
  - Peak demand 2MB
  - 4900 gal for generators / day
  - $10/gal (burdened)
  - $49,000 for generator fuel / day
  - $1.5M/mo; $18M / year

CH2MHILL Military Planning

Deloitte, Energy Security America's Best Defense, Study 2009

Value Proposition
Defense Applications

- Scalable power generation to meet any need
  - 5 watts to 15+ kilowatts
- Light weight enables portable solutions
- Excellent power density
- Voltages match battery ecosystem
- Ruggedized for defense applications



Ascent Solar Certification
MIL-STD-810G

- ✓ Sand
- ✓ Dust
- ✓ High Temp storage
- ✓ Low Temp storage
- ✓ Immersion
- ✓ Loose Cargo Vibration
- ✓ Thermal Shock
- ✓ Altitude
- ✓ Transit Drop
- ✓ Rain
- ✓ Salt-Fog

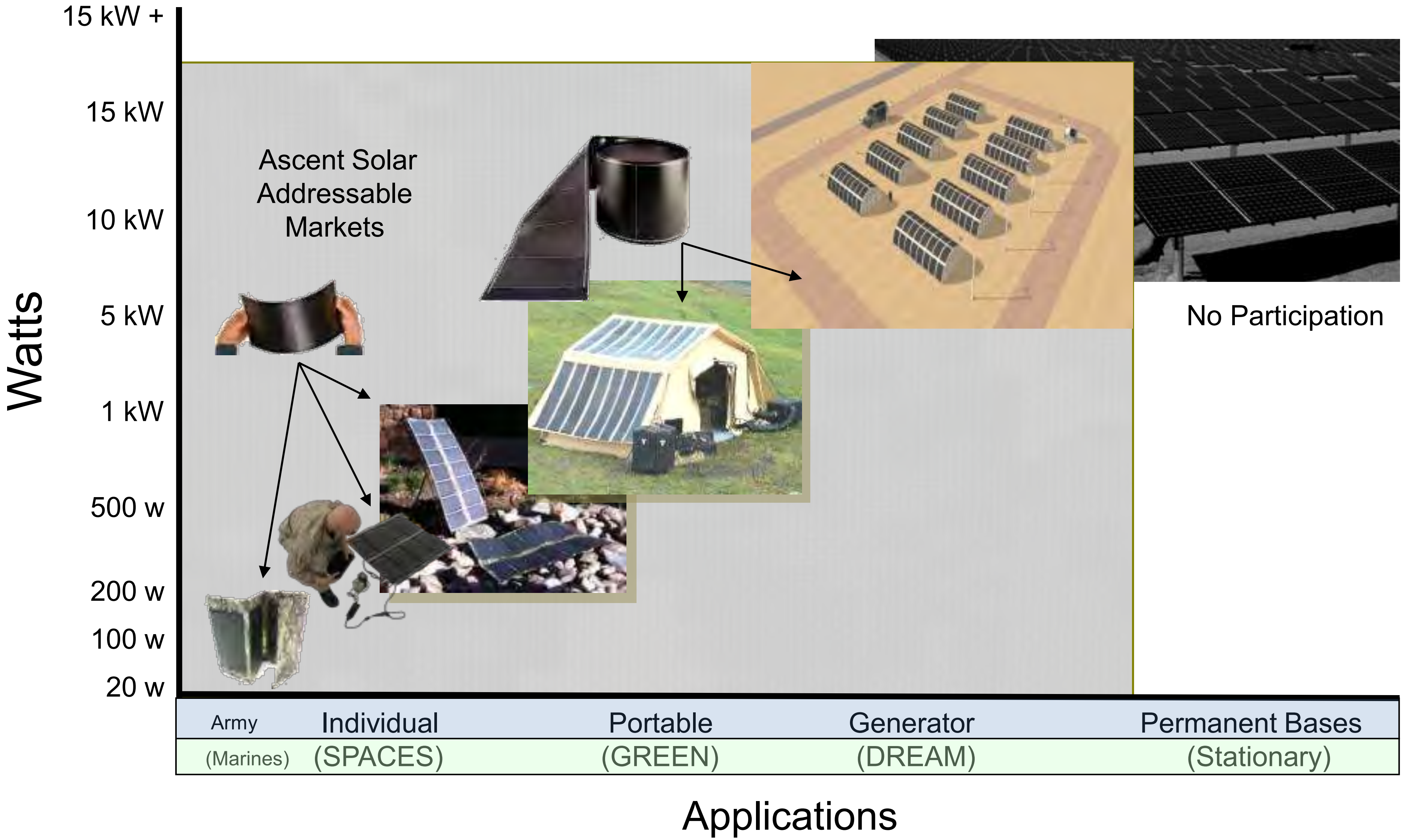

Rain


Vibration


Sand

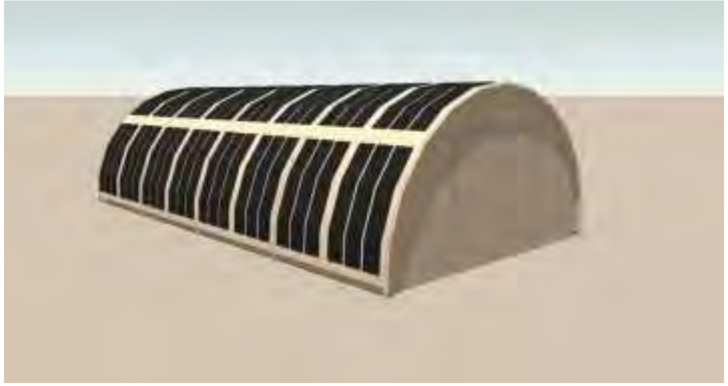

Transit drop

Where Ascent Plays



Current Defense Projects

Ascent Fabric laminated modules for large scalable system integration



Status:

Energy Technologies

- Ascent selected for two existing projects
- Received Air Force Research Lab order
  - Currently under AFRL Retest

2nd Customer Scalable Tent Fly

- Product design completed and under evaluation
- Scalable Tent Fly for large power generation of 1Kw to 15Kw+

Personnel Power

Ascent Products Integrated into
Samsonite Business Carrying Case
USA, February 2011

Ascent Solar USB
compact high power
mobile charging solution

Personnel Power
- Foldable and deployable power solution
- Power ranges from 5 to 120 watts

Samsonite
- Joint product development since 2010

Integrators
- Ascent technology being considered for complete replacement of a-Si across ecosystem

Distributors
- Specialized in portable power systems for Defense and Recreational use

Possible future applications

PV integrated into composites

PV integrated into vehicles

PV integrated into vessels

Ascent Solar Technologies

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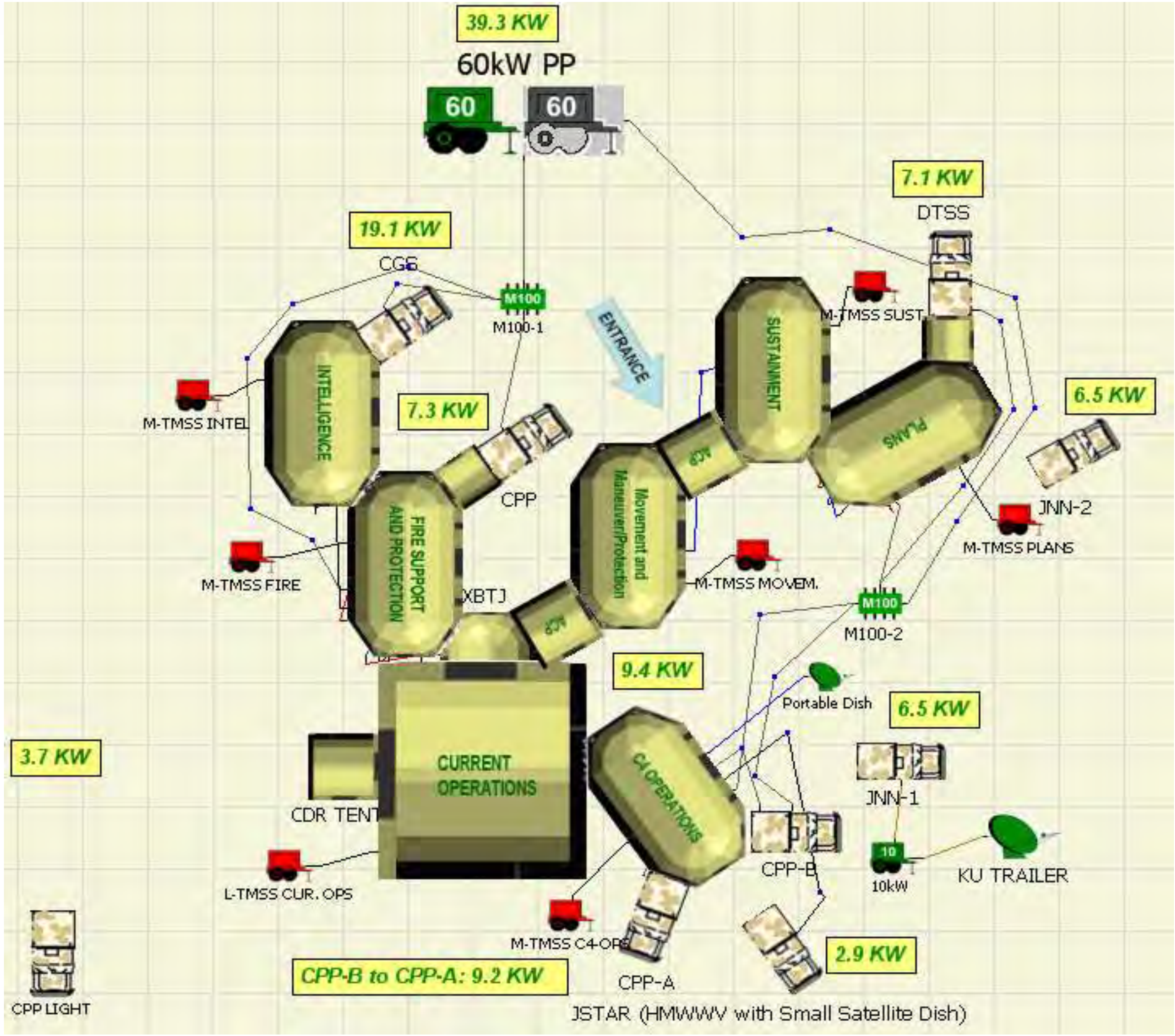
Fuel Consumption Model for Tactical Operations Centers (TOCs)

Jennifer Barker
SURVICE Engineering Company
Jennifer.barker@survice.com

Background

- CERDEC conducted a power assessment in 2008
  - Three Command Posts (CPs): the Brigade Main, the Infantry Battalion CP and the MAIN Tactical CP.
  - Eight days of mission equipment operation.
- AMSAA requested SURVICE Engineering Company conduct a study to account for the fuel consumed.
- By then end of the study, SURVICE had accounted for 97% of the reported fuel used during TOCFEST.
- Resulting model can be used to predict fuel usage for TOCs – any weather conditions, shelters, shelter configuration, mission equipment layout, generators, and ECUs.

BCT Main CP



39.3 KW
60kW PP
60
60
7.1 KW
DTSS
19.1 KW
CGS
M100
M100-1
ENTRANCE
SUSTAINMENT
M-TMSS SUST
INTELLIGENCE
M-TMSS INTEL
7.3 KW
6.5 KW
PLANS
ACP
CPP
Movement and Maneuver/Protection
JNN-2
FIRE SUPPORT AND PROTECTION
M-TMSS PLANS
M-TMSS FIRE
XBTJ
M-TMSS MOVEM.
M100
M100-2
ACP
9.4 KW
Portable Dish
6.5 KW
3.7 KW
CURRENT OPERATIONS
C4 OPERATIONS
JNN-1
CDR TENT
CPP-B
10
10kW
KU TRAILER
L-TMSS CUR. OPS
M-TMSS C4-OPS
2.9 KW
CPP-B to CPP-A: 9.2 KW
CPP-A
CPP LIGHT
JSTAR (HMWWV with Small Satellite Dish)

Problem Statement

Find: the fuel consumed by TMSSs during TOCFEST

Given:

- Total daily fuel usage & calculated fuel usage by power plants
- Shelter and mission equipment layouts
- Dates evaluated
- Weather conditions
- ECU capacities and TMSS fuel consumption rates

Tools:

- AutoDISE software
- HVAC Requirements calculator (part of AutoDISE)
- SURVICE Fuel Consumption Model

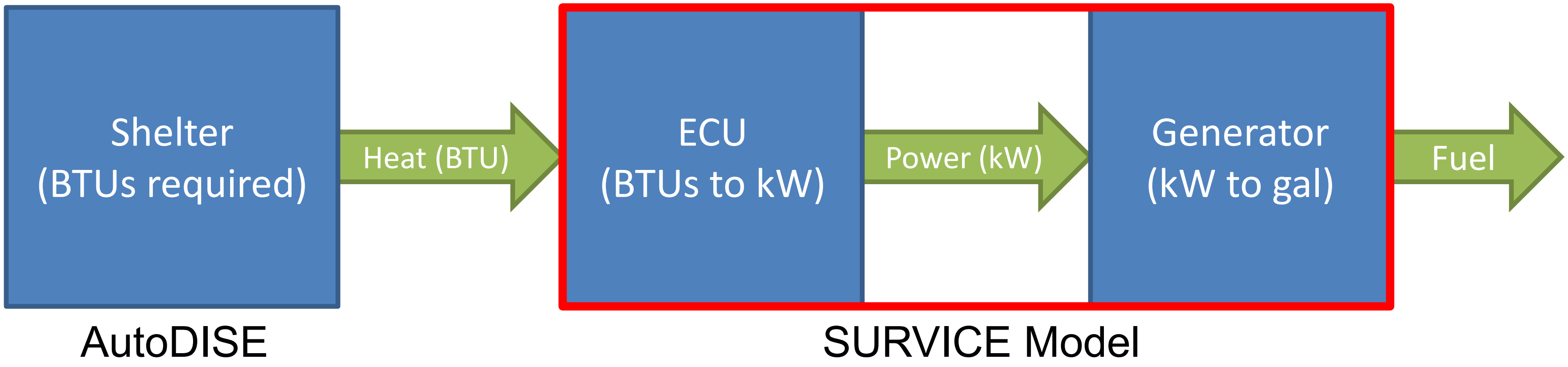
Additional Input

- Assumptions made in the following areas:
  - ECU settings
  - TOC hours of operation
  - # personnel in each shelter
  - Conditions within shelters
  - Ground conditions
  - Solar and electrical contribution to heat load

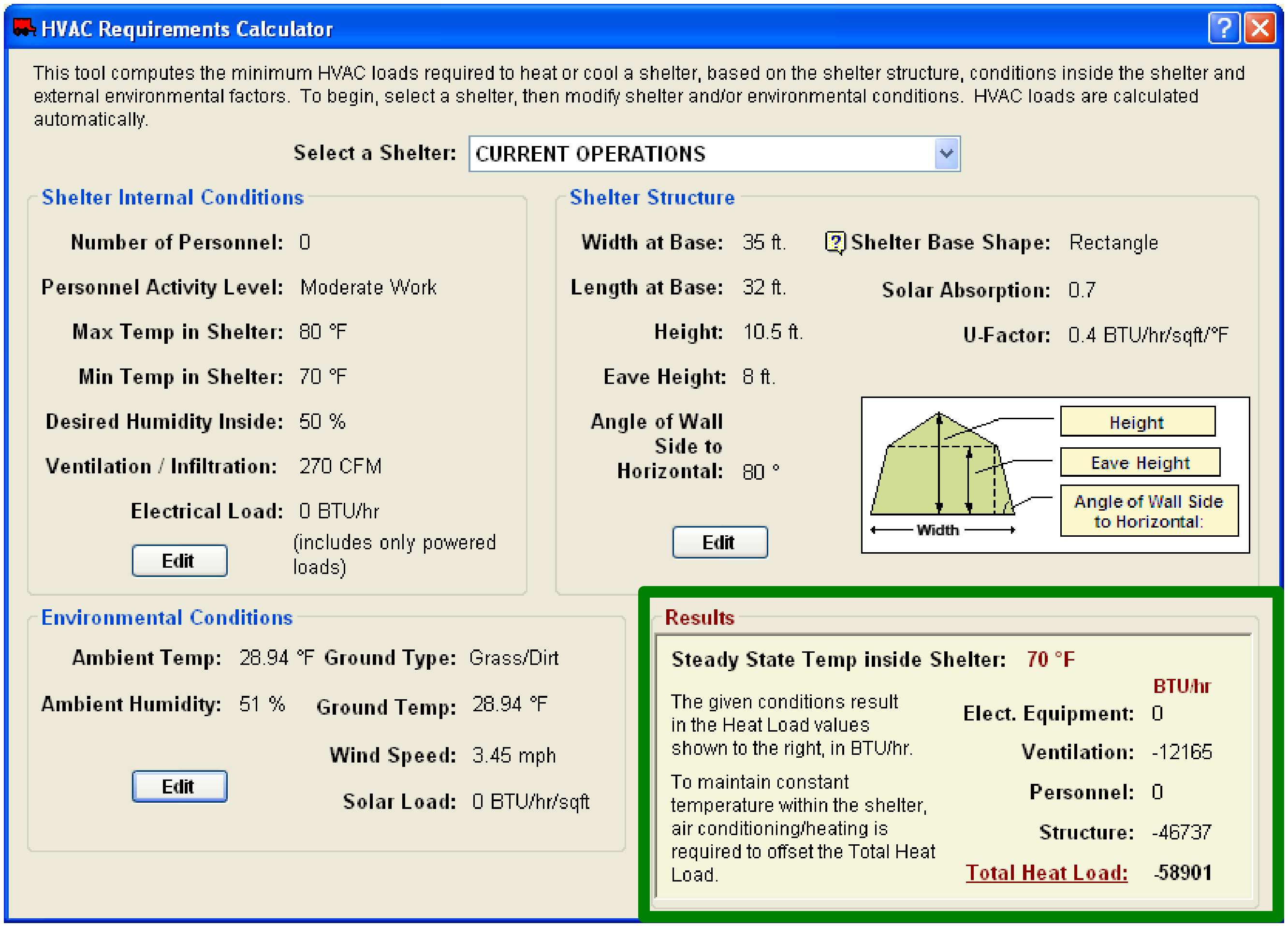
Approach

Determine:

- Heating required (BTUs)
- Electrical Power to generate heating (BTU to kW)
- Fuel to produce total power (kW to gal)



HVAC Requirements Calculator



SURVICE ENGINEERING COMPANY

AutoDISE Input/Output

Shelter: Fire Support and Protection

Inputs to AutoDISE	
# of Personnel	12
Activity Level	moderate
Max Temp in shelter (°F)	80
Min Temp in shelter (°F)	70
Desired humidity inside (%)	50
Ventilation/Infiltration (CFM)	120

Color Codes:	Conditional Formatting	
Enter into AutoDISE	Power to heat/cool ...	Cooling Required
Values returned by AutoDISE	Power to heat/cool ...	Heating Required
TMSS used (note the ref. in the formulas to the Medium/Large TMSS	Power to heat/cool ...	No Heating/Cooling necessary
	% Time ECU Running/NOT Runn	Heating/Cooling not required for this setting, fuel calculated at no load
Not used - TMSS not running	% Time ECU Running/NOT Runn	Heating/Cooling required is more than ECU can provide, consider adjusting settings

		Inputs to AutoDISE					Calculated from AutoDISE					Power to heat/cool all connected
Date (by hour)	Time (by hour)	Ambient Temp (°F)	Ground Temp (°F)	Ambient Humidity (%)	Wind Speed (mph)	Solar Load ($BTU/hr/ft^2$)	Steady-State Temp (degrees F)	Electrical Equipment (BTU/hr)	Ventilation (BTU/hr)	Personnel (BTU/hr)	Structure (BTU/hr)	(BTU/hr)
3/27/2008	5:59 AM	36.32	36.32	77%	0.00	0	70.0	0	-4,435	0	-15,498	-26,703
3/27/2008	6:59 AM	33.62	33.62	85%	0.00	0	70.0	0	-4,790	0	-16,558	-28,625
3/27/2008	7:59 AM	33.62	33.62	85%	0.00	0	70.0	0	-4,790	0	-16,558	-28,625
3/27/2008	8:59 AM	33.62	33.62	88%	0.00	0	70.0	0	-4,790	0	-16,558	-28,625
3/27/2008	9:59 AM	33.8	33.8	86%	0.00	0	70.0	0	-4,767	0	-16,488	-28,498
3/27/2008	10:59 AM	35.96	35.96	83%	0.00	0	70.0	0	-4,482	0	-15,640	-26,960
3/27/2008	11:59 AM	36.14	36.14	85%	2.30	0	70.0	0	-4,458	0	-22,507	-36,455
3/27/2008	12:59 PM	38.48	38.48	82%	0.00	0	70.0	0	-4,150	0	-14,643	-25,154
3/27/2008	1:59 PM	43.16	43.16	67%	0.00	0	70.0	0	-3,534	0	-12,766	-21,768
3/27/2008	2:59 PM	42.62	42.62	78%	0.00	0	70.0	0	-3,605	0	-12,984	-22,161
3/27/2008	3:59 PM	42.8	42.8	87%	4.60	0	70.0	0	-3,582	0	-19,413	-31,046
3/27/2008	4:59 PM	46.4	46.4	73%	8.06	0	70.0	0	-3,107	0	-17,655	-28,002
3/27/2008	5:59 PM	45.5	45.5	73%	6.90	0	70.0	0	-3,226	0	-18,107	-28,780
3/29/2008	5:59 AM	35.42	35.42	53%	9.21	0	70.0	0	-4,553	0	-25,401	-40,675
3/29/2008	6:59 AM	34.34	34.34	53%	3.45	0	70.0	0	-4,695	0	-24,446	-39,442
3/29/2008	7:59 AM	33.62	33.62	53%	3.45	0	70.0	0	-4,790	0	-24,908	-40,203
3/29/2008	8:59 AM	33.08	33.08	57%	4.60	0	70.0	0	-4,861	0	-25,825	-41,561
3/29/2008	9:59 AM	32.36	32.36	58%	4.60	0	70.0	0	-4,956	0	-26,299	-42,339
3/29/2008	10:59 AM	32.18	32.18	59%	6.90	0	70.0	0	-4,980	0	-27,169	-43,571
3/29/2008	11:59 AM	33.26	33.26	46%	6.90	0	70.0	0	-4,838	0	-26,435	-42,373
3/29/2008	12:59 PM	34.34	34.34	45%	6.90	0	70.0	0	-4,695	0	-25,701	-41,174
3/29/2008	1:59 PM	35.24	35.24	40%	13.81	0	70.0	0	-4,577	0	-26,063	-41,519
3/29/2008	2:59 PM	37.22	37.22	38%	11.51	0	70.0	0	-4,316	0	-24,442	-38,943
3/29/2008	3:59 PM	38.66	38.66	38%	11.51	0	70.0	0	-4,127	0	-23,431	-37,302
3/29/2008	4:59 PM	40.64	40.64	36%	5.75	0	70.0	0	-3,866	0	-21,165	-33,834
3/29/2008	5:59 PM	43.16	43.16	33%	9.21	0	70.0	0	-3,534	0	-20,035	-31,842
3/30/2008	5:59 AM	28.94	28.94	51%	3.45	0	70.0	0	-5,407	0	-27,913	-45,153
3/30/2008	6:59 AM	28.04	28.04	52%	8.06	0	70.0	0	-5,525	0	-30,274	-48,566
3/30/2008	7:59 AM	27.68	27.68	50%	5.75	0	70.0	0	-5,572	0	-29,858	-48,053
3/30/2008	8:59 AM	26.24	26.24	45%	4.60	0	70.0	0	-5,762	0	-30,327	-48,949
3/30/2008	9:59 AM	24.44	24.44	49%	4.60	0	70.0	0	-5,999	0	-31,510	-50,890
3/30/2008	10:59 AM	24.26	24.26	50%	3.45	0	70.0	0	-6,023	0	-30,913	-50,097
3/30/2008	11:59 AM	27.32	27.32	47%	3.45	0	70.0	0	-5,620	0	-28,952	-46,865
3/30/2008	12:59 PM	29.48	29.48	42%	2.30	0	70.0	0	-5,335	0	-26,620	-43,273
3/30/2008	1:59 PM	33.62	33.62	40%	8.06	0	70.0	0	-4,790	0	-26,443	-42,321
3/30/2008	2:59 PM	35.6	35.6	35%	6.90	0	70.0	0	-4,530	0	-24,844	-39,777
3/30/2008	3:59 PM	39.92	39.92	33%	10.36	0	70.0	0	-3,961	0	-22,424	-35,695

Fuel Consumption Calculations

Medium TMSS

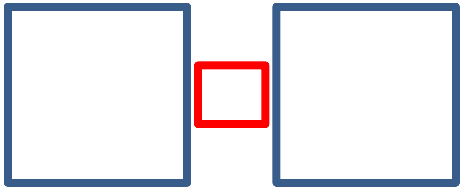
ettings

Power to heat/cool all connected	Low Heat (LowHeat on, only heating when too cold): % of time ECU Running	% of time ECU NOT Running	Fuel Consumed (ECU Running)	Fuel Consumed (ECU NOT Running)	Total Low Heat Fuel (gal) 54.73 — Total Fuel	High Heat (High Heat on, only heating when too cold): % of time ECU Running	% of time ECU NOT Running	Fuel Consumed (ECU Running)	Fuel Consumed (ECU NOT Running)	Total High Heat Fuel (gal) 101.20 — Total Fuel
	(assume low setting)		(assume low setting)	(assume no load)	(Running + No Load)	(assume high setting)		(assume high setting)	(assume no load)	(Running + No Load)
(BTU/hr)	(%)	(%)	(gal/hr)		(gal/hr)	(%)	(%)	(gal/hr)		(gal/hr)
-26,703	89%	11%	0.48	0.04	0.52	45%	55%	0.65	0.21	0.86
-28,625	95%	5%	0.52	0.02	0.53	48%	52%	0.70	0.20	0.90
-28,625	95%	5%	0.52	0.02	0.53	48%	52%	0.70	0.20	0.90
-28,625	95%	5%	0.52	0.02	0.53	48%	52%	0.70	0.20	0.90
-28,498	95%	5%	0.51	0.02	0.53	47%	53%	0.69	0.20	0.89
-26,960	90%	10%	0.49	0.04	0.52	45%	55%	0.66	0.21	0.87
-36,455	122%	-22%	0.54	0.00	0.54	61%	39%	0.89	0.15	1.04
-25,154	84%	16%	0.45	0.06	0.51	42%	58%	0.61	0.22	0.83
-21,768	73%	27%	0.39	0.10	0.50	36%	64%	0.53	0.24	0.77
-22,161	74%	26%	0.40	0.10	0.50	37%	63%	0.54	0.24	0.78
-31,046	103%	-3%	0.54	0.00	0.54	52%	48%	0.76	0.18	0.94
-28,002	93%	7%	0.50	0.03	0.53	47%	53%	0.68	0.20	0.88
-28,780	96%	4%	0.52	0.02	0.53	48%	52%	0.70	0.20	0.90
-40,575	135%	-35%	0.54	0.00	0.54	68%	32%	0.99	0.12	1.11
-39,442	131%	-31%	0.54	0.00	0.54	66%	34%	0.96	0.13	1.09
-40,203	134%	-34%	0.54	0.00	0.54	67%	33%	0.98	0.13	1.10
-41,561	139%	-39%	0.54	0.00	0.54	69%	31%	1.01	0.12	1.13
-42,339	141%	-41%	0.54	0.00	0.54	71%	29%	1.03	0.11	1.14
-43,571	145%	-45%	0.54	0.00	0.54	73%	27%	1.06	0.10	1.16
-42,373	141%	-41%	0.54	0.00	0.54	71%	29%	1.03	0.11	1.14
-41,174	137%	-37%	0.54	0.00	0.54	69%	31%	1.00	0.12	1.12
-41,519	138%	-38%	0.54	0.00	0.54	69%	31%	1.01	0.12	1.13
-38,943	130%	-30%	0.54	0.00	0.54	65%	35%	0.95	0.13	1.08
-37,302	124%	-24%	0.54	0.00	0.54	62%	38%	0.91	0.14	1.05
-33,834	113%	-13%	0.54	0.00	0.54	56%	44%	0.82	0.17	0.99
-31,842	106%	-6%	0.54	0.00	0.54	53%	47%	0.77	0.18	0.95
-45,153	151%	-51%	0.54	0.00	0.54	75%	25%	1.10	0.09	1.19
-48,566	162%	-62%	0.54	0.00	0.54	81%	19%	1.18	0.07	1.25
-48,053	160%	-60%	0.54	0.00	0.54	80%	20%	1.17	0.08	1.24
-48,949	163%	-63%	0.54	0.00	0.54	82%	18%	1.19	0.07	1.26
-50,890	170%	-70%	0.54	0.00	0.54	85%	15%	1.24	0.06	1.30
-50,097	167%	-67%	0.54	0.00	0.54	83%	17%	1.22	0.06	1.28
-46,865	156%	-56%	0.54	0.00	0.54	78%	22%	1.14	0.08	1.22
-43,273	144%	-44%	0.54	0.00	0.54	72%	28%	1.05	0.11	1.16
-42,321	141%	-41%	0.54	0.00	0.54	71%	29%	1.03	0.11	1.14
-39,777	133%	-33%	0.54	0.00	0.54	66%	34%	0.97	0.13	1.10
-35,695	119%	-19%	0.54	0.00	0.54	59%	41%	0.87	0.15	1.02
-32,845	109%	-9%	0.54	0.00	0.54	55%	45%	0.80	0.17	0.97
-29,483	98%	2%	0.53	0.01	0.54	49%	51%	0.72	0.19	0.91

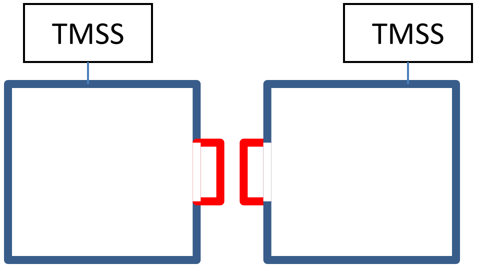
Common Conditions

- TMSS ECU COP = 1 (Resistance heating)
- Fuel for HMMWV's not included in analysis
- Distribution of Connector tent heat load

Actual Layout



Heat load calculated separately

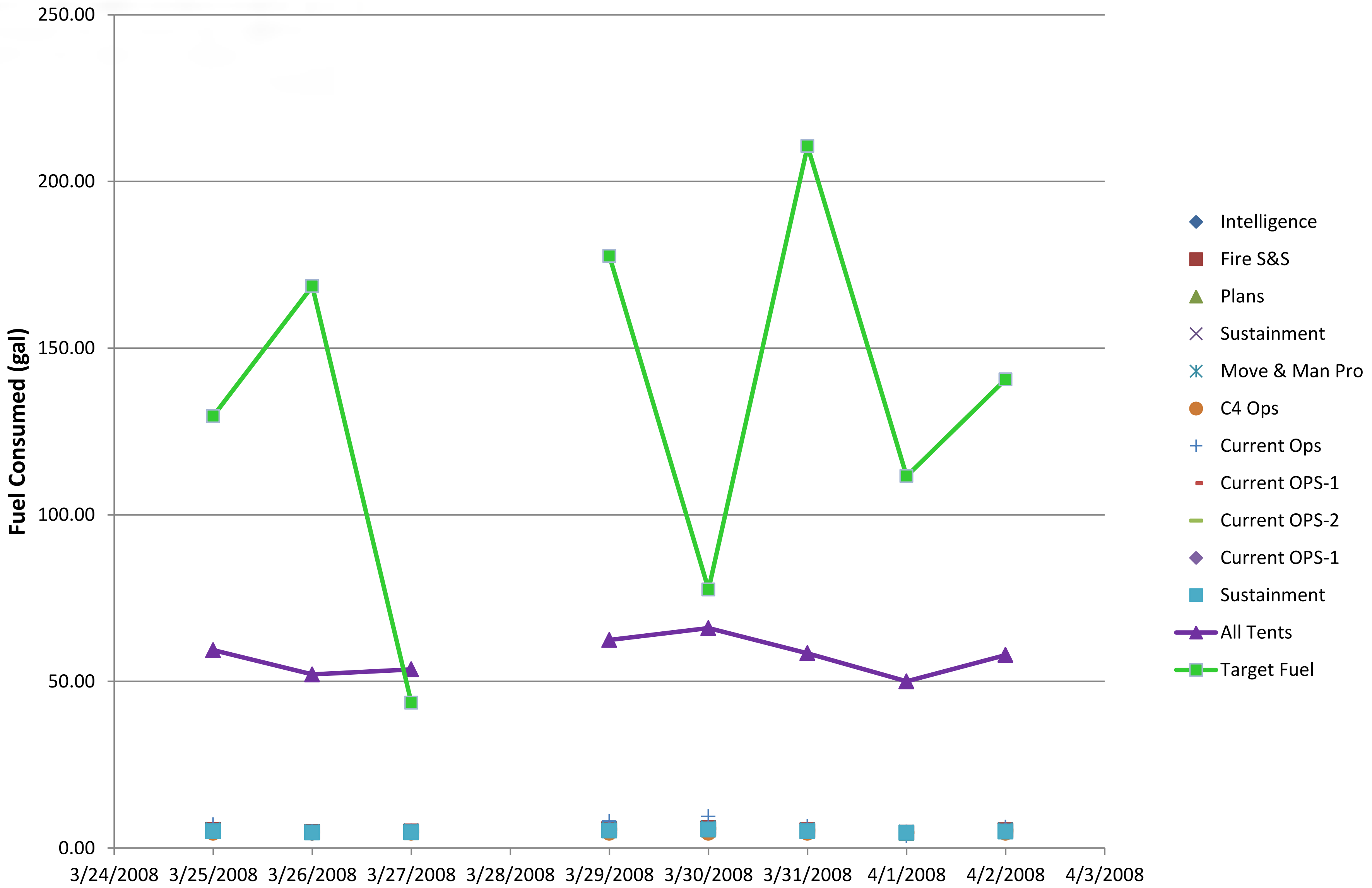


Heat Load Distributed

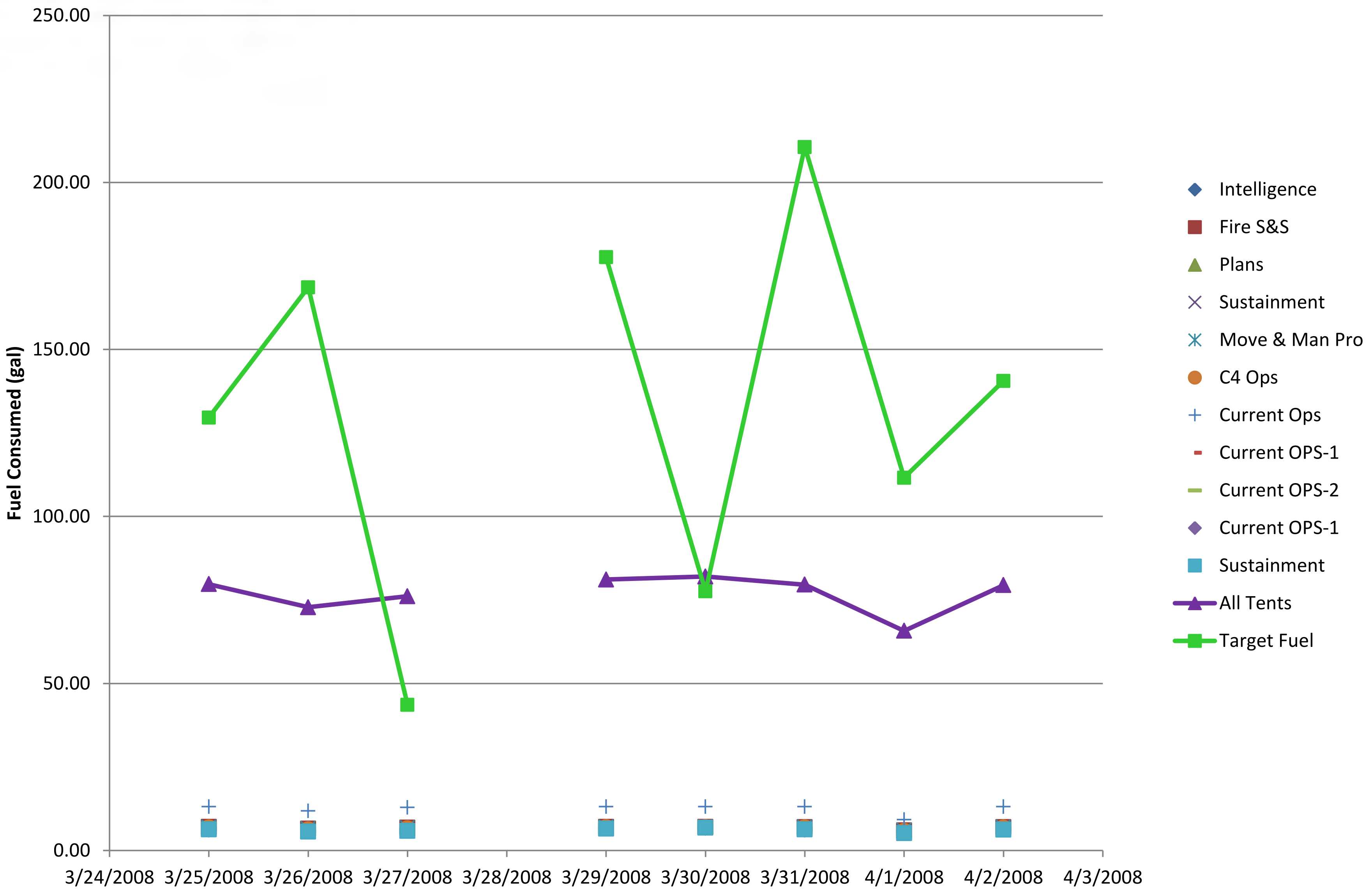
Study Conditions

	Scenario 1 (Original Assumptions)	Scenario 2	Scenario 3
Heat Setting	Low	Low	High
Hours of Operation	0600-1800	0600-1900	0600-1900
# Personnel	# laptop stations	0	0
Internal Temperature	65-80°F	70-80°F	70-80°F
Desired Humidity	50%	50%	50%
Ventilation/Infiltration	# laptop stations	# laptop stations	# laptop stations
Ground Type	Dirt/grass	Dirt/grass	Dirt/grass
Ground Temperature	Air temperature	Air temperature	Air Temperature
Solar Load	0 BTU/hr	0 BTU/hr	0 BTU/hr
Conversion of Electrical Load to Heat Load	100%	0%	0%

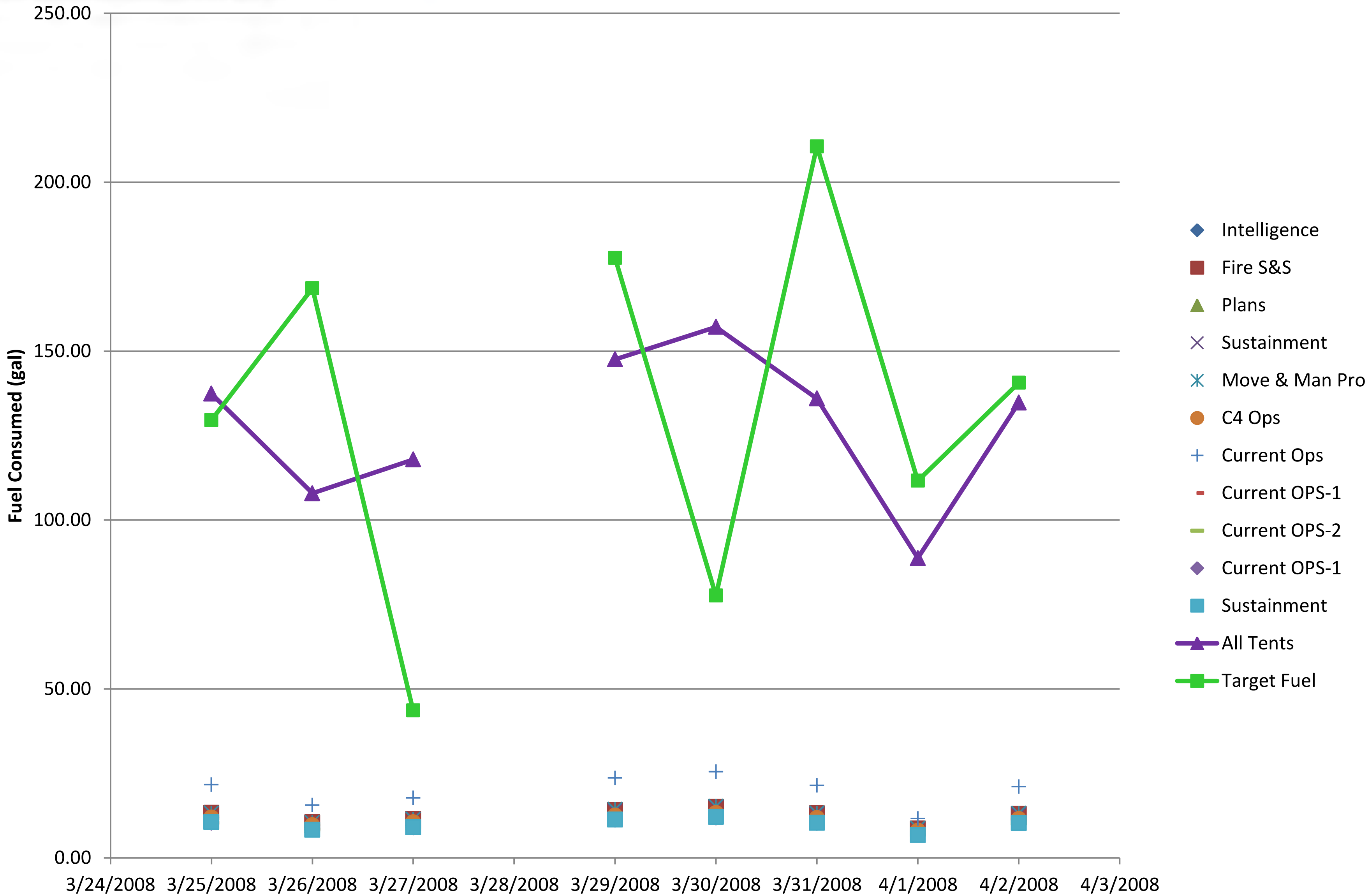
Scenario 1 Fuel Consumption



Scenario 2 Fuel Consumption



Scenario 3 Fuel Consumption



Fuel Consumption (gals)

Date	Scenario 1	Scenario 2	Scenario 3	Consumed by TMSSs
3/25/2008	61.40	79.74	137.37	129.6
3/26/2008	52.75	72.80	107.88	168.6
3/27/2008	54.53	76.10	117.88	43.6
3/28/2008				
3/29/2008	64.99	81.13	147.54	177.6
3/30/2008	69.25	82.00	157.13	77.6
3/31/2008	60.22	79.58	135.95	210.6
4/1/2008	50.40	65.77	88.71	111.6
4/2/2008	59.61	79.45	134.73	140.6
Total	473.15	616.58	1027.18	1059.8

Conclusion

- SURVICE model had accounted for 97% of the reported fuel used during TOCFEST.
- Resulting model can be used to predict fuel usage for TOCs – any weather conditions, shelters, shelter configuration, mission equipment layout, generators, and ECUs.
- The model shows what factors can significantly affect fuel usage.

SURVICE ENGINEERING COMPANY

BACKUP

Potential Fuel Consumption

based on Fuel Consumption Data from CERDEC

Generator Operating Conditions	TMSS Size	Fuel Consumption (gal/hr)	Daily Fuel Consumption (12 hrs/day) (gal/day)	8-day total Fuel Consumption (gal)	Qty of TMSS size in TOC	Fuel Consumed per TMSS size (8-day total) (gal)	Potential Fuel Usage for TOCFEST (gal)
Full Load	Medium	1.46	17.52	140.16	10	1401.6	1629.12
	Large	2.37	28.44	227.52	1	227.52	
Half Load	Medium	0.54	6.48	51.84	10	518.4	615.36
	Large	1.01	12.12	96.96	1	96.96	
No Load	Medium	0.38	4.56	36.48	10	364.8	388.8
	Large	0.25	3	24	1	24	

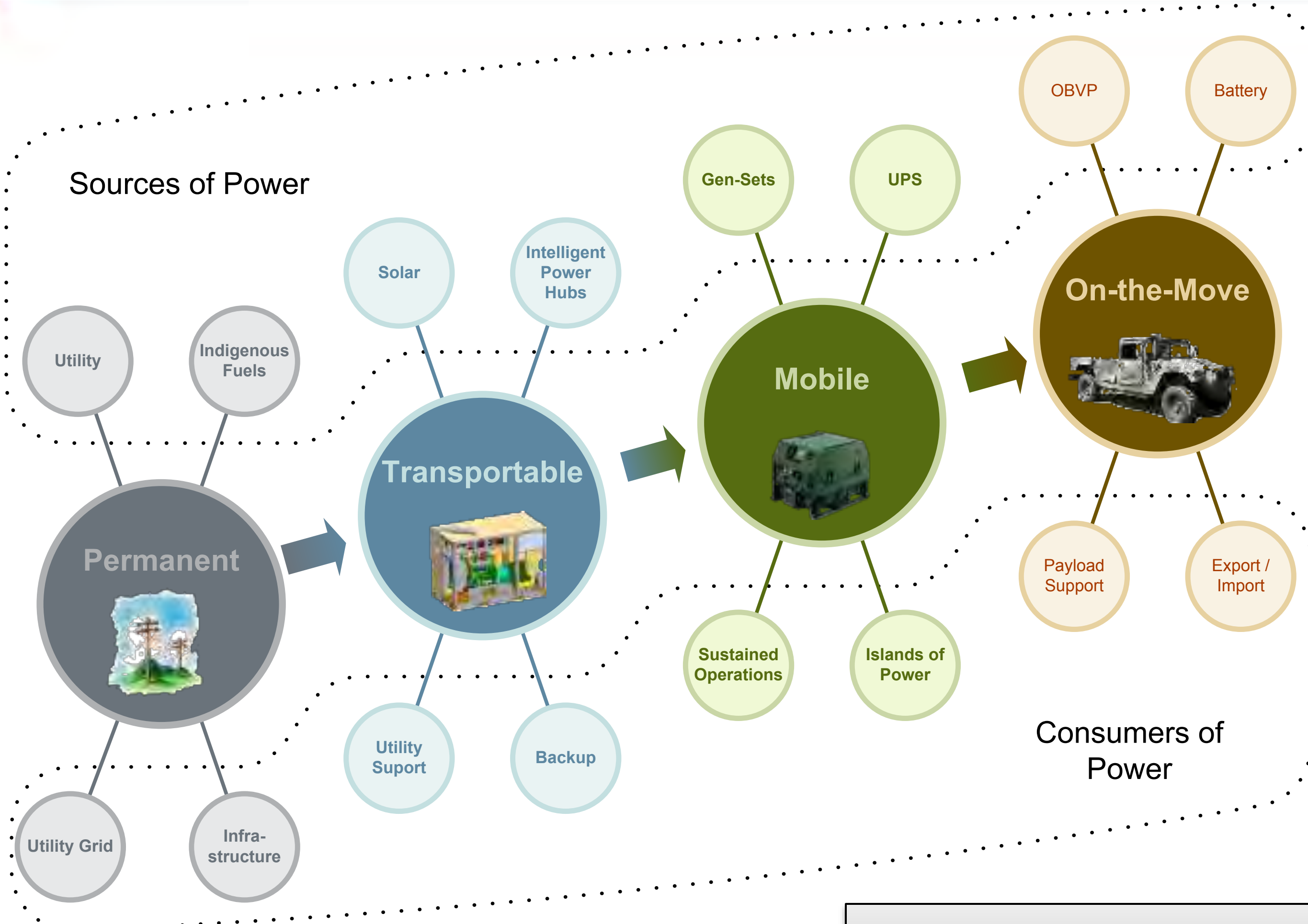
Recorded fuel used during TOCFEST	1231	
Report estimated fuel consumption by PP	171.2	14%
Report estimated fuel consumption by TMSS's	1059.8	86%

Integrating Power Plants into Powertrains

2011 Joint Service Power Expo

05 May 2011

Battlefield Power



Pushing mission power forward to the warfighter

On-Board Vehicle Power (OBVP)

New Capability at Reduced Logistics Costs

Existing Configuration to Deliver 30 kW with HMMWV Class Vehicle

HMMWVs

15 kW Generators

Soldiers

30 kW

Weight = 20,800 lbs
Volume = 1,504 ft^3

USMC OBVP Equipped HMMWV Configuration Delivers 30 kW

HMMWV OBVP

Soldiers

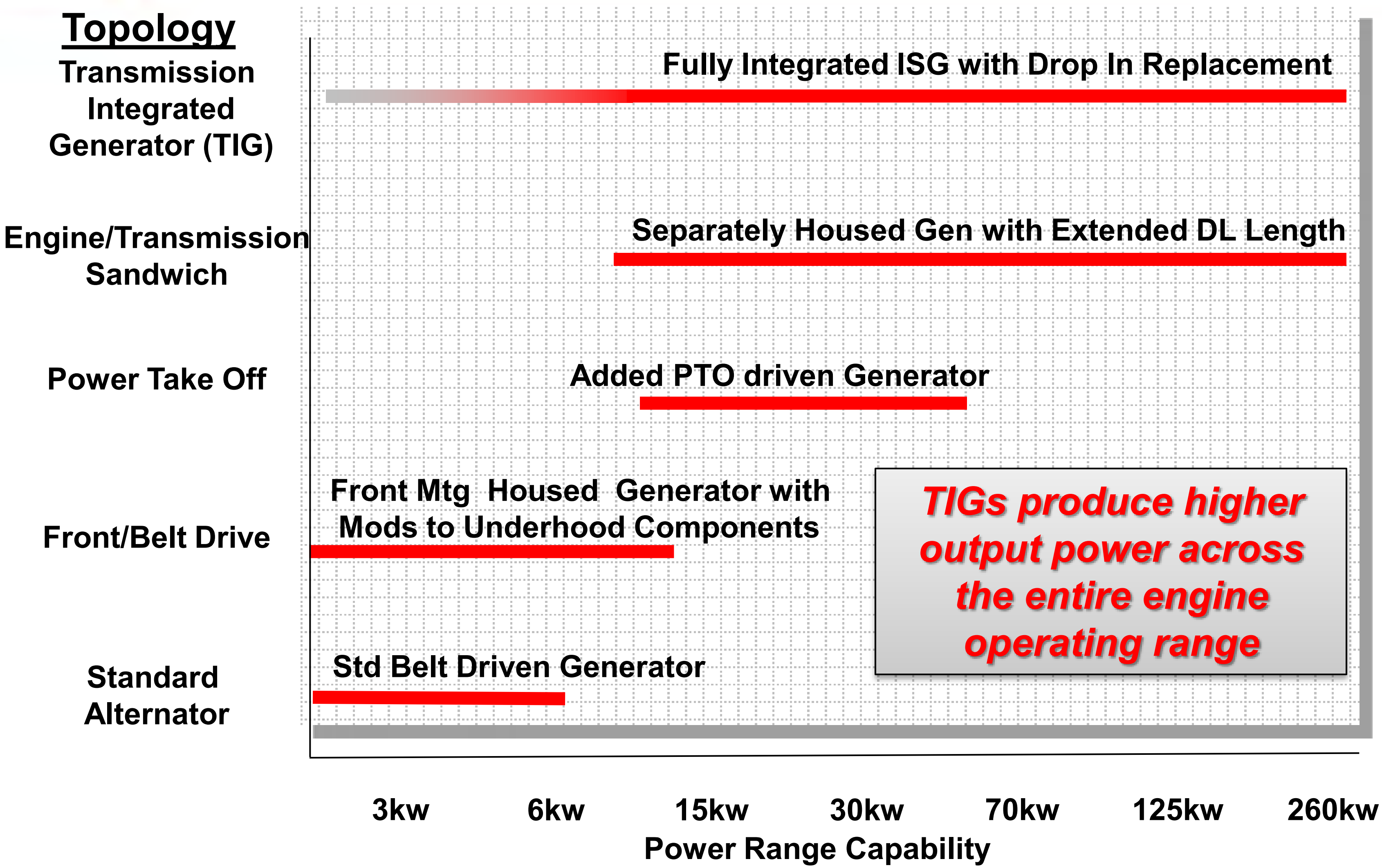
30 kW

Weight = 6,912 lbs
Volume = 637 ft^3

66% Weight Reduction
58% Volume Reduction
50% Manning Reduction

Significant logistics savings achieved using HMMWV OBVP Technology.
Program transitioned to MCSC PM Expeditionary Power Systems.

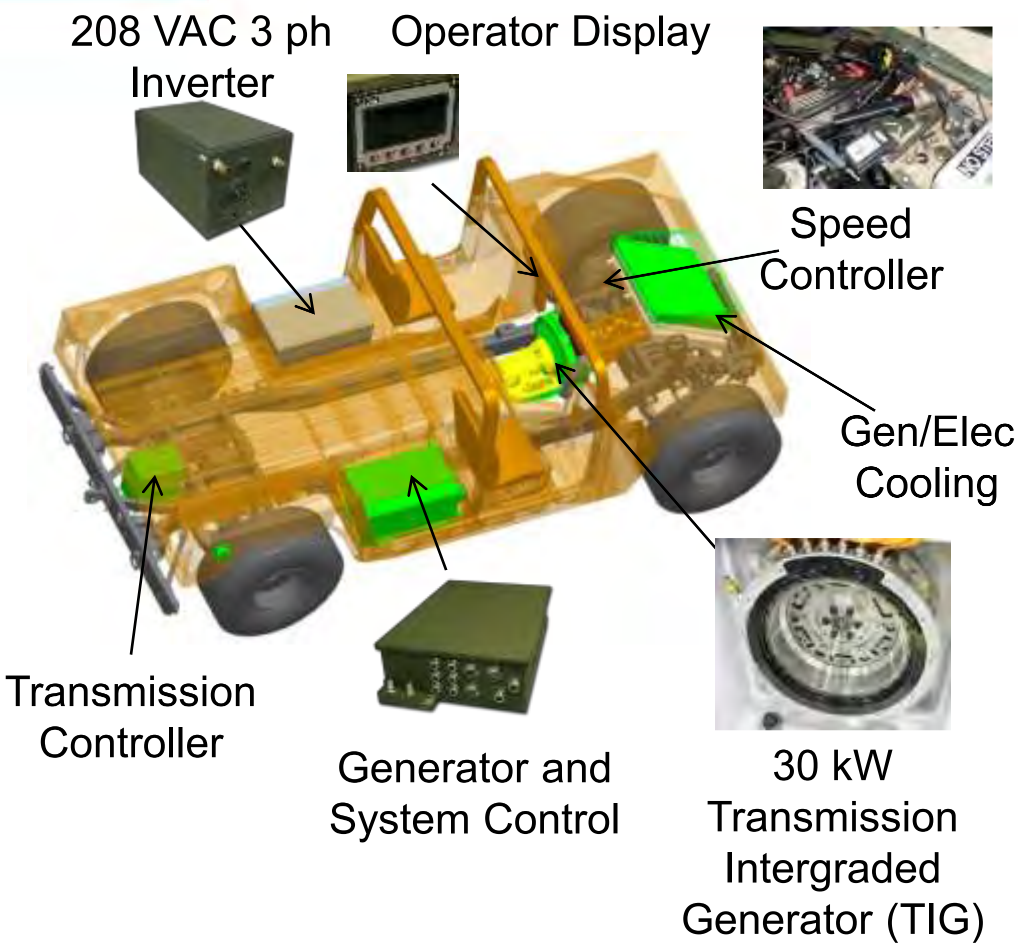
Vehicle Power Solution Approaches



Transmission Integral Generators

The Basis of the DRS OBVP System

Meeting the Needs



- ***<u>30 K-Watts exportable power continuous – for stationary Ops</u>***
- 10 K-W power-***<u>on-the-move</u>***
- Transmission Embedded PM Generator
- ***<u>No Increase in driveline length</u>***
- ***<u>No belts / pulleys / bearings / shafts / seals / mounts</u>***
- ***<u>No additional periodic maintenance</u>***
- Active Generator Controller
- Power Conditioning Modules:
  - **120/208 VAC / 28 VDC**
  - **Single and three phase**

OBVP Equipped HMMWV's have been successfully tested at APG and used in field trials by both Navy and SOCOM

Integration Challenges

User Interface
- System Control
- Status Information
- Fault Reporting
- Safety

Driveability
- Monitored Performance Feedback
- Shift Schedules
- Load Management

Mechanical Loads
- Rear Engine PTO
- Electric / Hydraulic
- Electric / Mechanical

User Interface

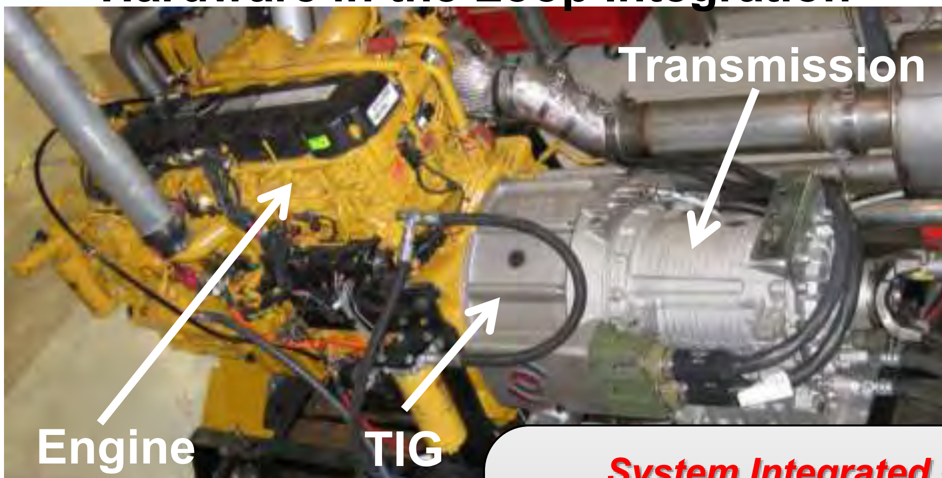
Functions

- System control
- Status information
- Fault reporting and corrective actions
- Safety / E-Stop

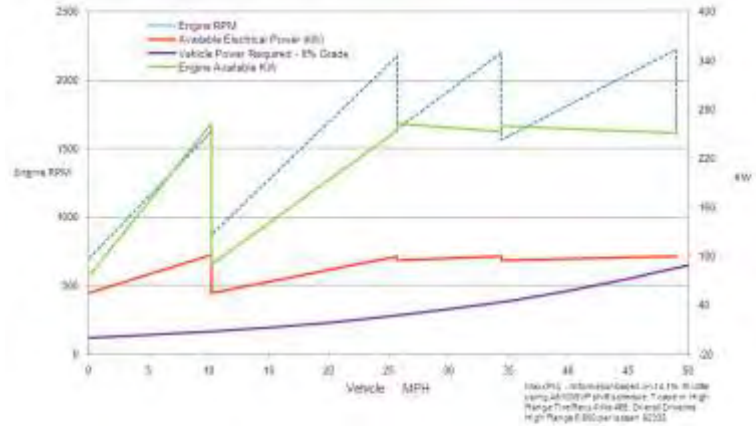
The Operator's focus on system operation is defined by the User Interface

Optimized for Driveability

Hardware in the Loop Integration

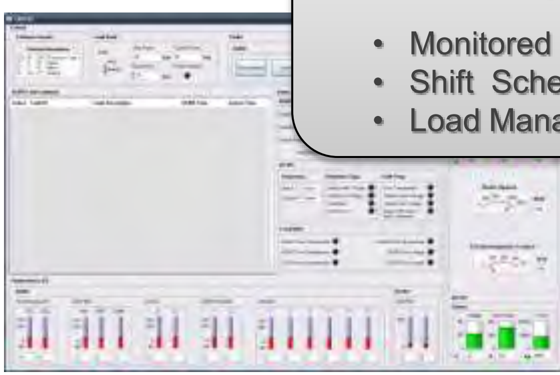


Modeling & Simulation

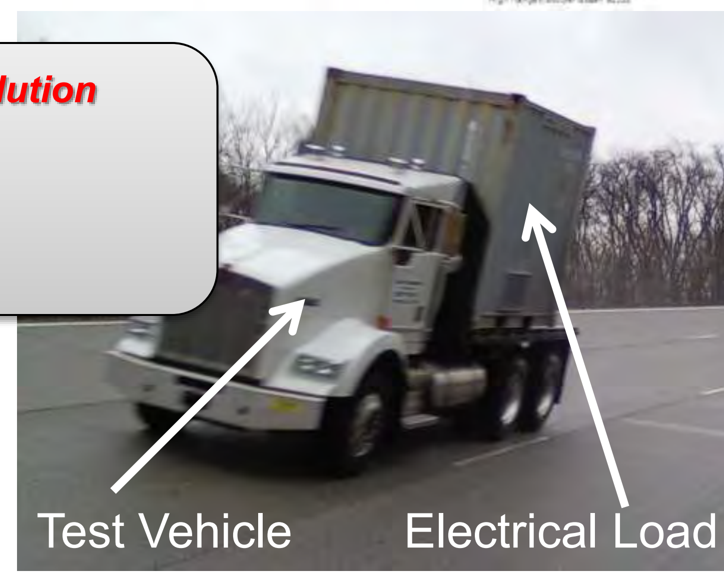


System Integrated OBVP Solution
Optimizes Driveability

- Monitored Performance Feedback
- Shift Schedules
- Load Management



Data Acquisition & Control



On-Vehicle Evaluation

Mechanical Loads

Rear Engine PTO

Electric / Hydraulic

Electric / Mechanical

Options are available to replace mechanical systems and transmission based PTO

Summary

- Total system integration of an OBVP solution provides optimized driveability
- Options are readily available to address mechanical systems and the transmission PTO
- The OBVP User Interface defines the operator’s interaction with the system
- TIG based OBVP systems can meet the needs to fight today’s fight and tomorrow’s

THANK YOU!

DRS TECHNOLOGIES

A Finmeccanica Company

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Permanent Magnet Generators for On Board Vehicle Power

Jim Burns
Mark Harris

May 5, 2011

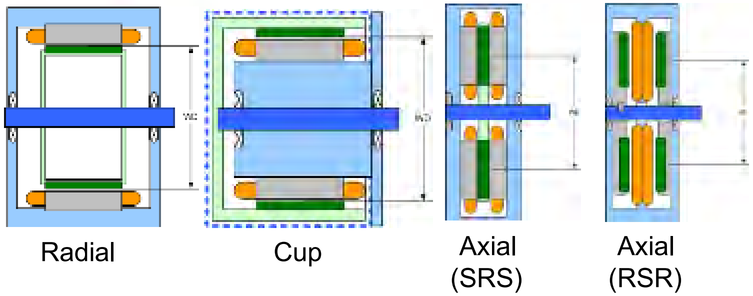
DRS Power Technology, Inc.
A Finmeccanica Company

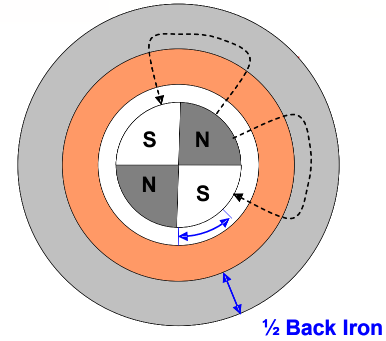
Distribution Statement A

Approved for public release;
distribution is unlimited.

DRS TECHNOLOGIES

Benefits of Permanent Magnet (PM) Machines





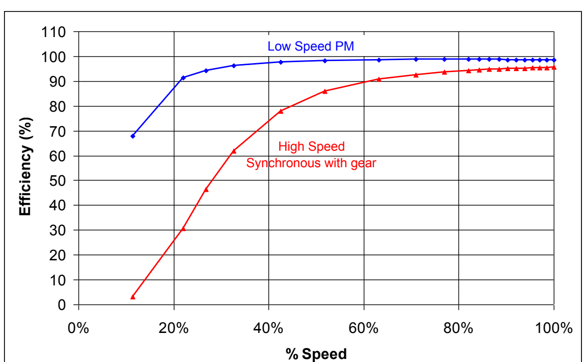
Simple & Compact
Permanent Magnet Motor

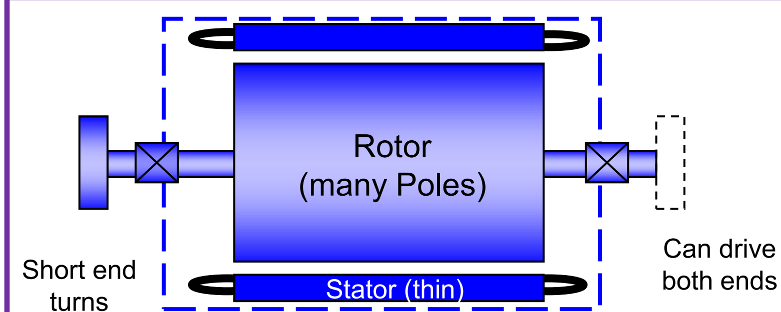
Flexible topologies

Robust

High power density

Efficiency across speed range





Relevant DRS PTI OBVP PM Experience

PA44

- 450hp @ 2860 RPM (825 ft-lb)
- 1475 ft-lb at stall
- 25.5” D x 8.8” L
- 395 lbs

PA57

- 1000hp @ 3600 RPM (1450 ft-lb)
- 2000 ft-lb at stall
- 31” D x 10.5” L
- 780 lbs

Motor Model Series Designators:
PA = Permanent Magnet Axial Field
PR = Permanent Magnet Radial Field
PC = Permanent Magnet Cup Motor

PR40

- 33kW @ 1800 RPM (130 ft-lb)
- 21.2” D x 4.7” L
- 113 lbs

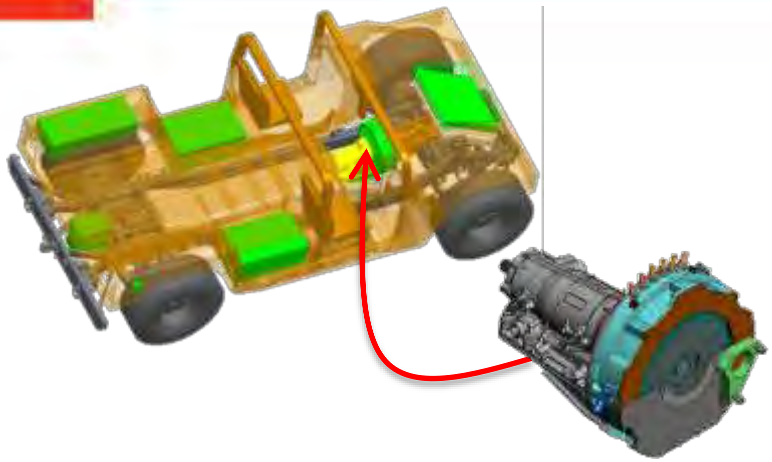
PC36

- 240hp @ 4600 RPM (275 ft-lb)
- 500 ft-lb at stall
- 18” D x 7.2” L
- 139 lbs

PC45

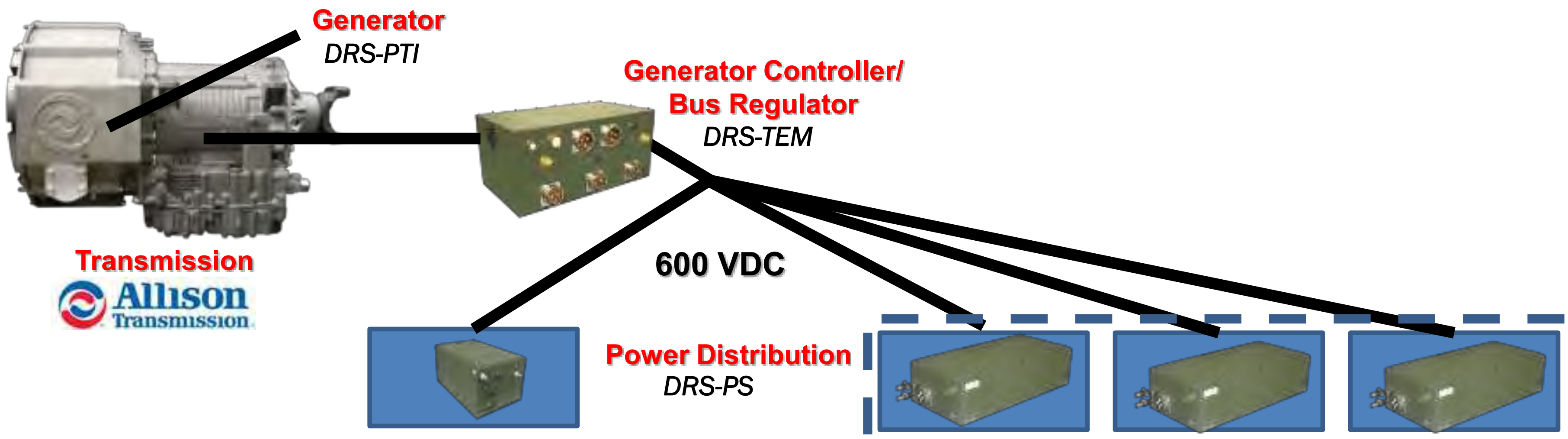
- 115+kW @ 1700 RPM (480 ft-lb)
- 60kW constant
- 19.3” D x 10.1” L
- 241 lbs

DRS Approach to OBVP – Driveline Integration



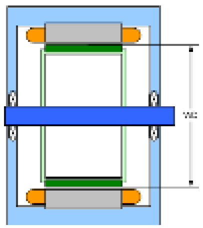
Advantages:

- No effect on driveline overall length
- One unit… similar to replacing a transmission
- Rear crankshaft power draw
- Suitable for starter functionality
- High torque, low speed



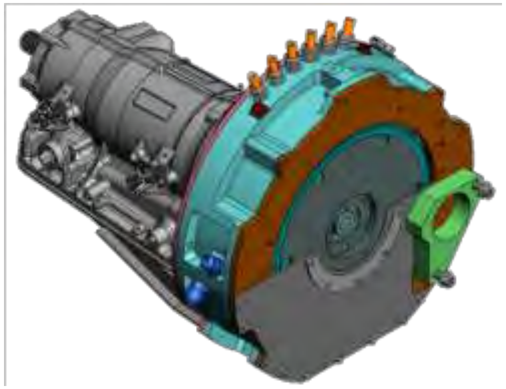
System-level view, solid teaming, and tight integration (mechanical and electrical) critical to solution development

PR40 Permanent Magnet Generator



Radial PMG:

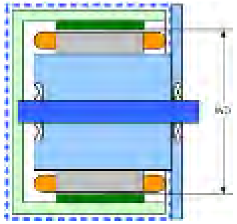
- Works within available space outboard of the torque converter (GTP 4L80 transmission)
- Rotor assembly replaces the flywheel
- Starting ring gear incorporated into motor rotor
- 33kW @ 1800 RPM (130 ft-lb)
- 10kW on-the-move
- 21.2” D x 4.7” L, 113 lbs
- 400 VDC system output (controller setting)
- 95C coolant



PR40 Status

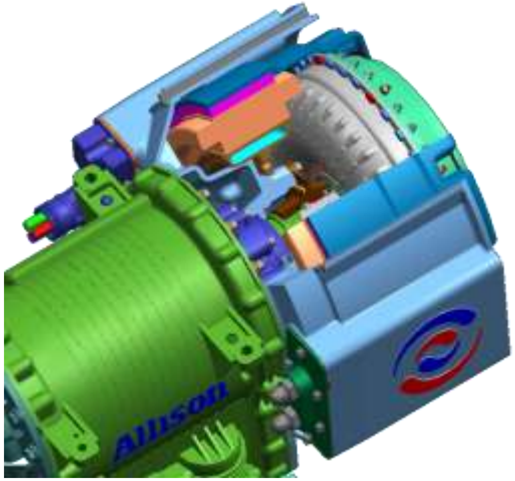
- 1 Development Vehicle, 1 Bid Sample Vehicle, 1 Pre-production Deliverable, 15 units on order by USMC and in production. 1 full system SIL (test cell test bed) used for continued development and refinement of hardware, software, and expanded kit
- 2 vehicles passed mobile electric power test sequence at proving ground. 1 vehicle passed basic proving ground driving sequence (5,000 miles). Pre-production at or going to APG for completion of OBVP power and vehicle checks.
- DRS establishing capability for continued low rate builds. Continuing work on kit cost reduction and capability envelope expansion.

PC45 Permanent Magnet Generator



Cup PMG:

- Most suitable for space made available by removal of the mechanical PTO (ATI 3200 MSG transmission)
- Evolution of PR40 integration… true TIG (Transmission Integral Generator)
- 60kW constant
- 19.3” D x 10.1” L, 241 lbs
- 600 VDC system output (controller setting)
- 80C coolant



PC45 Status

- One unit in System Integration Lab (full system test cell)
- One unit in test mule durability runs (driveline plus containerized power kit and loads)
- One unit for TARDEC SIL
- On-going LUT/LRIP preparations

Conclusions

- Permanent magnet generators offer many advantages for OBVP
- DRS Technologies has breadth and depth of relevant PMG experience
- Several benefits with transmission integral solutions

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Advanced Power Systems for Enhanced Capability and Fuel Economy

Captain Lynn Petersen, USN
PMS 320
Deputy Director

5 May 2011

Agenda

- *Fuel and Capability : Navy Leadership Perspective*
- *The Situation*
- *War Fighting Needs Drives Power Systems*
- *The Problem*
- *Technology Similarity: Land and Sea*
- *The Challenge: Irregular Sources and Loads*
- *The Solution*
- *Technology Approach*
- *Conclusions*
- *Acknowledgments*

Fuel and Capability – Leadership Perspective

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ESO
Directing the Future of Ships Power

"simply rely too much on...depleting stocks of fossil fuels..."

"goal has got to be increased warfighting capability"

"in every case, adoption of new energy tech has led to a strategic advantage for the country"

"remove barriers that will inhibit our ability to get enhanced capability into the hands of our Sailors quickly"

"increase our energy security and operational effectiveness by reducing our reliance on fossil fuels"

"We're roughly two percent of all the oil that is consumed in the United States. We ought to move ahead, and it isn't just the military that has to [change], we all have to do it, but the military can serve as an early adopter."

The Situation

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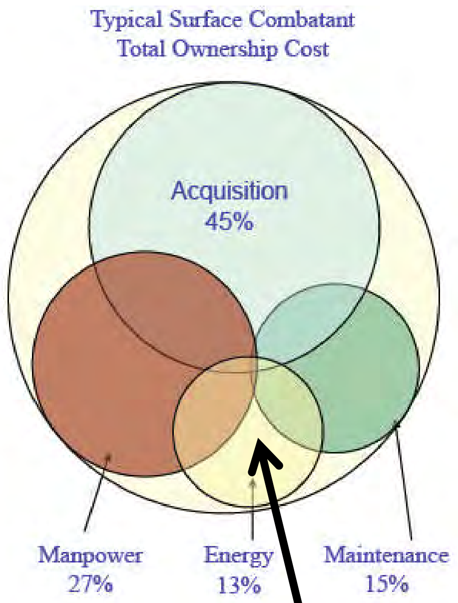
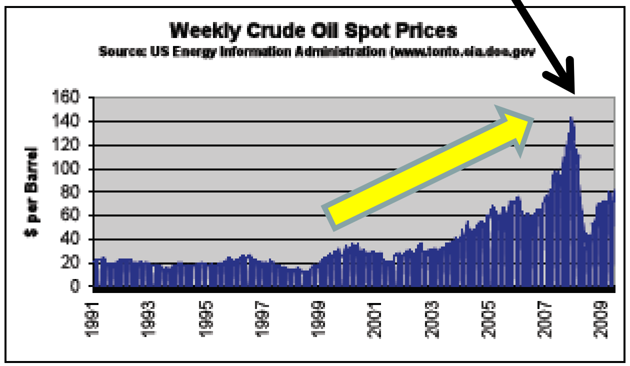
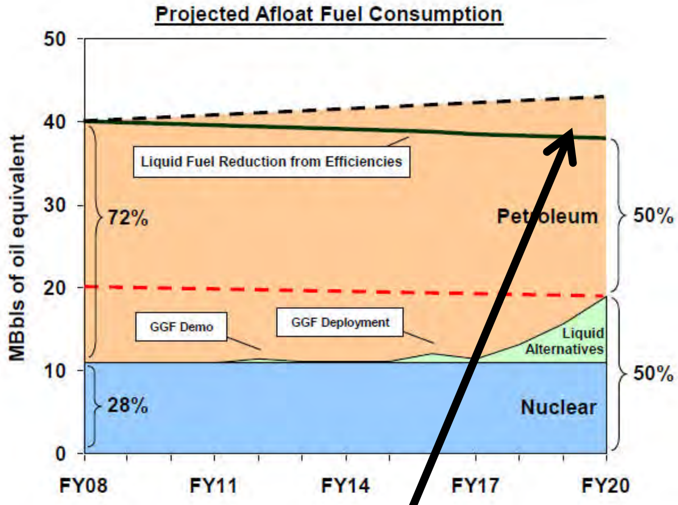
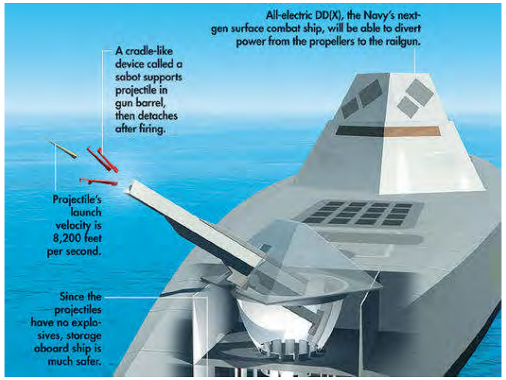


Energy is a substantial And growing cost element





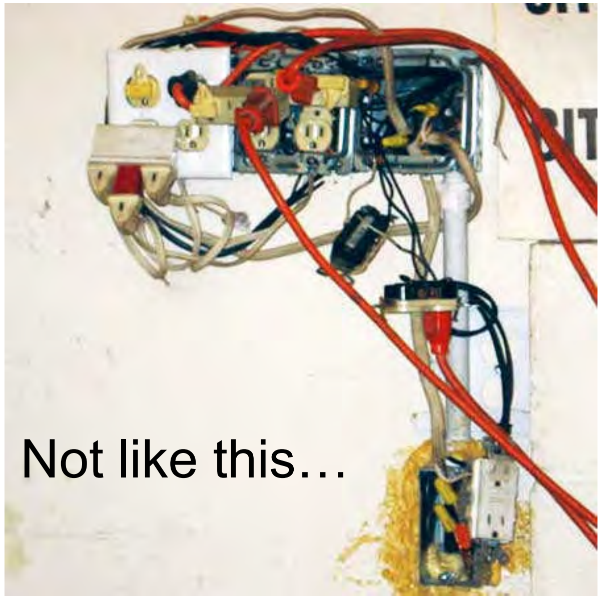
Consumption reduction critical to controlling cost and maintaining capability in light of new load requirements.



Looking Forward

New threats and technology development are leading to better and more power hungry solutions in sensors and weapons.

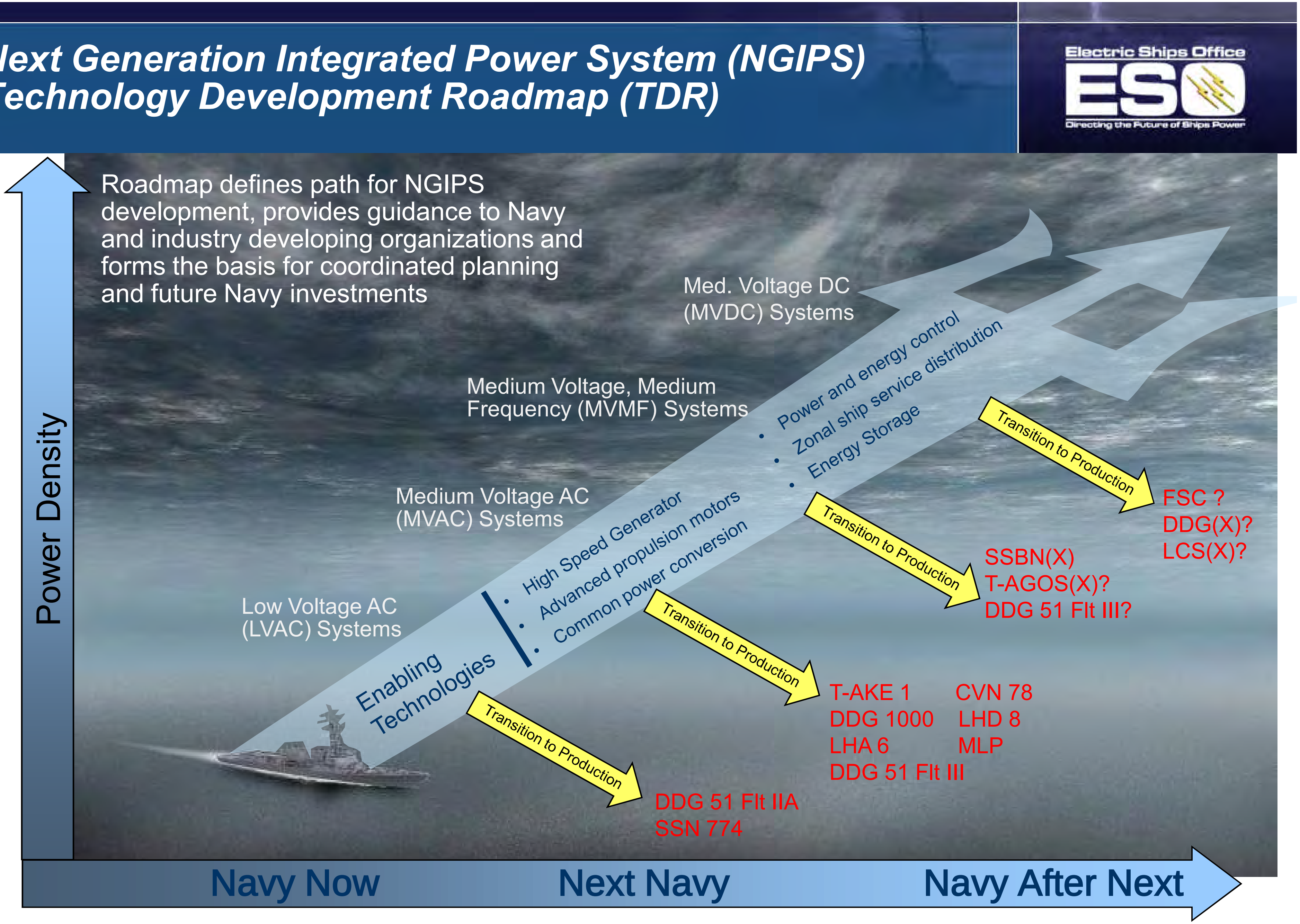
How do you address this on both current and future platforms?



Executing the NGIPS Technology Development Roadmap Paramount

Courtesy of Mr. Dwight Alexander, Northrop Grumman

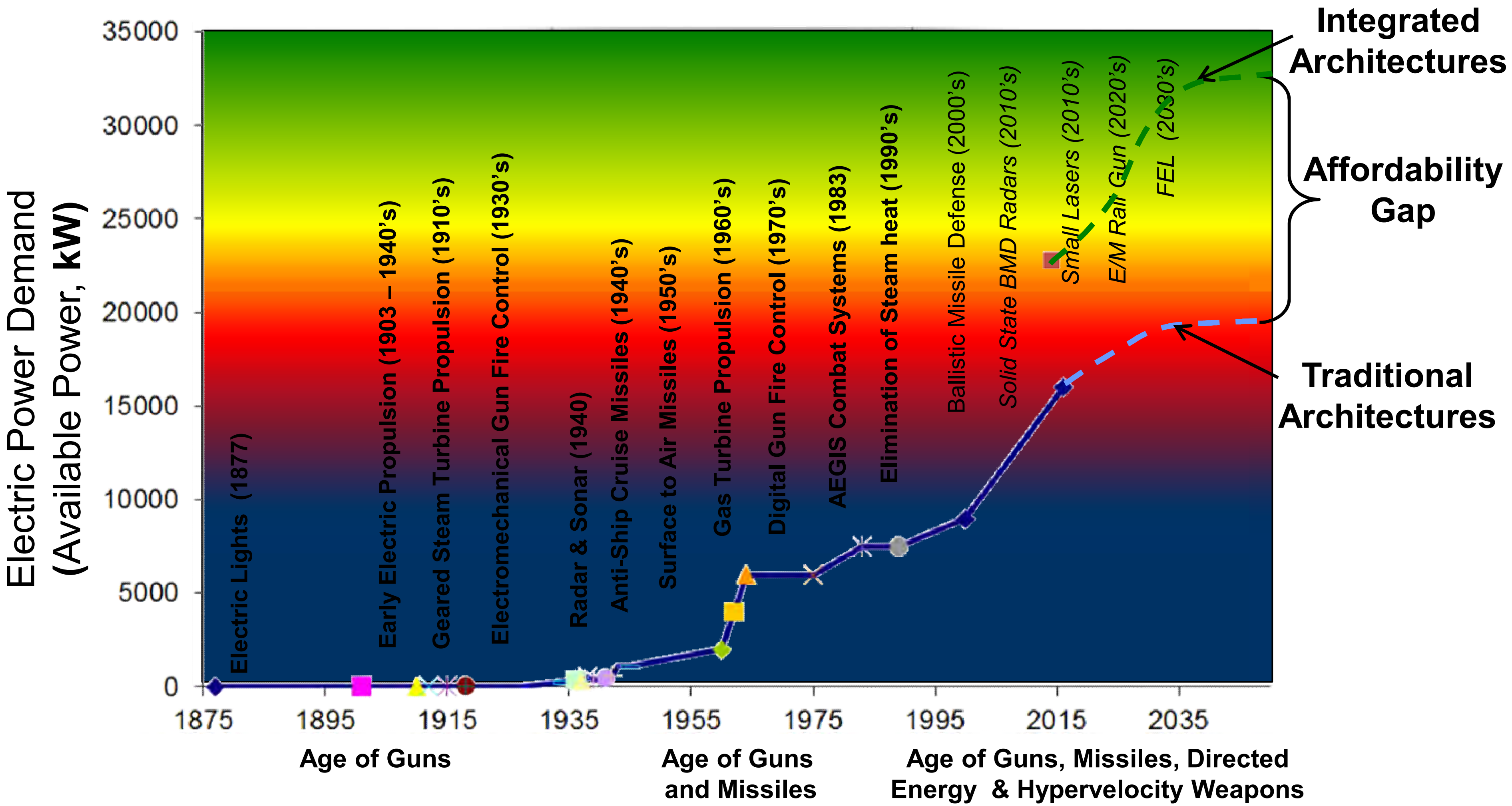
Next Generation Integrated Power System (NGIPS) Technology Development Roadmap (TDR)



“Directing the Future of Ships Power”

War fighting Needs Drive Power Systems

Electric Ships Office ESO Directing the Future of Ships Power



Integrated Architectures meet requirements at lower cost

The Problem

National Power & Energy

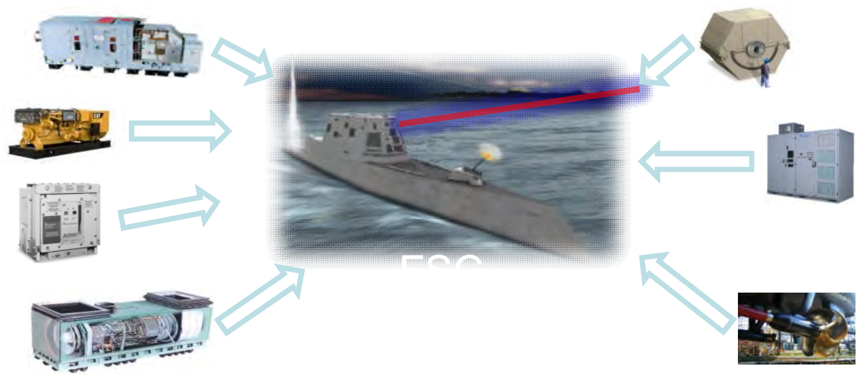
- Critical to
  - National security
  - Economic growth
  - Public health & safety
- Current/Future demands
  - Greater reliability/resiliency
    - Increased situational awareness
    - Faster response to faults/failures
    - Higher intrinsic reliability
  - More flexibility
    - Shift from centralized to market driven command and control
  - Increased energy security
    - Shift away from dependence on foreign oil

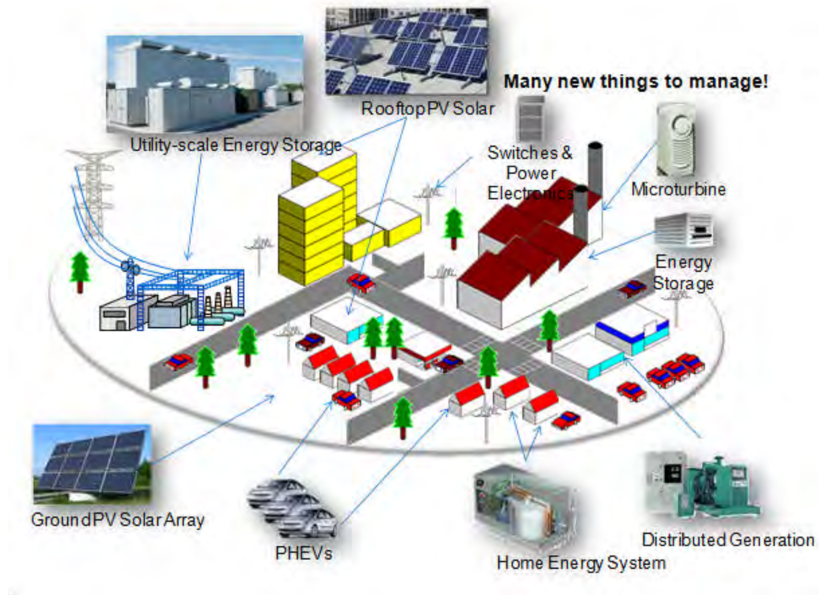
Military Power & Energy

- Critical to
  - Power projection
  - Base security & operations
  - Warfighter health & safety
- Current/Future demands
  - Greater reliability/resiliency
    - Increased situational awareness
    - Faster response to faults/failures
    - Higher intrinsic reliability
  - More flexibility
    - Shift toward IPS and HED
    - Shift toward increased automation for command and control
  - Increased energy security
    - Shift away from dependence on foreign oil
    - Reduce risk to Warfighter

The Military and National power and energy systems face many of the same challenges

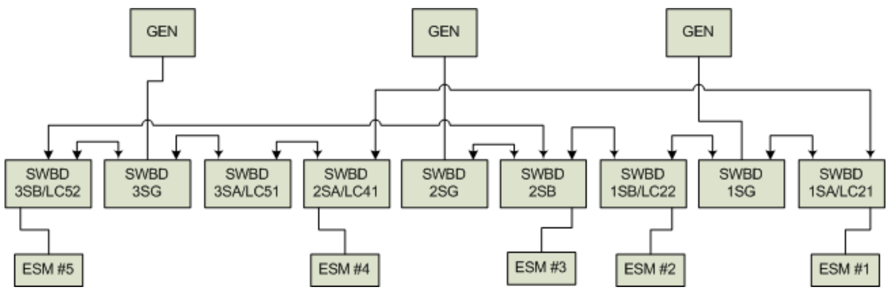
Technology Similarity – Land and Sea

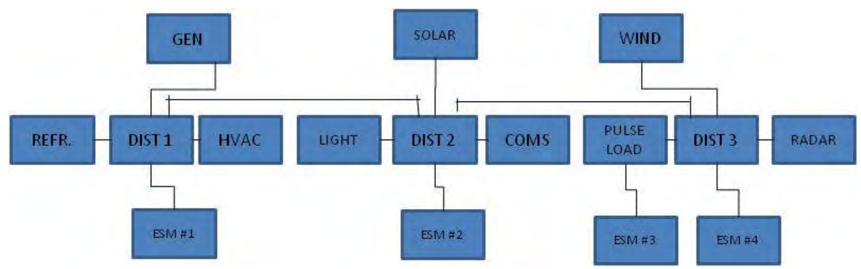




At Sea

On Land





Technological Needs Are Similar

Safe, efficient systems are critical to adoption and widespread use

Multiple-rate, high power/energy systems with appropriate thermal Characteristics are necessary for adoption

Commercial

Storage at Grids Edge

Transportation

Military

Ships

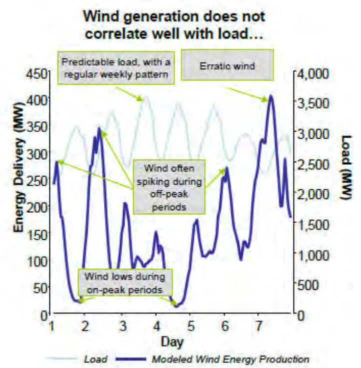
Aircraft

Subs

Vehicles

Commercial

Grid Stabilization



Military

High Rate Weapons & Sensors

Forward Operating Bases

Generator Ride Through

USN History of Electric Ships: Micro grids Nothing New to the Navy

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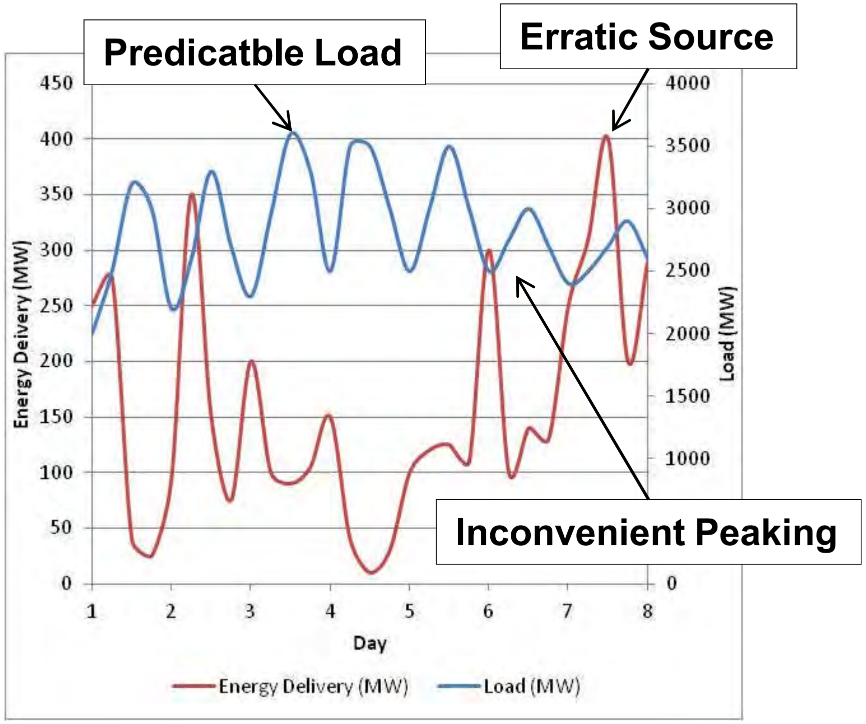
Photo # NH 63407 USS Trenton reefing top sails, circa the mid-1880s

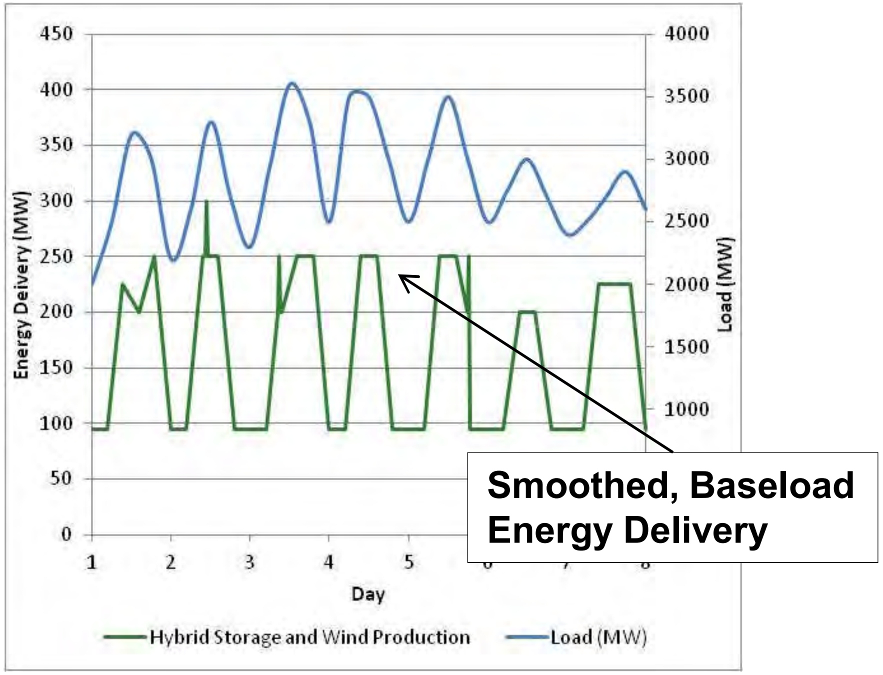
Photo # NH 81279 USS Langley off San Diego, California, with USS Somers, 1928

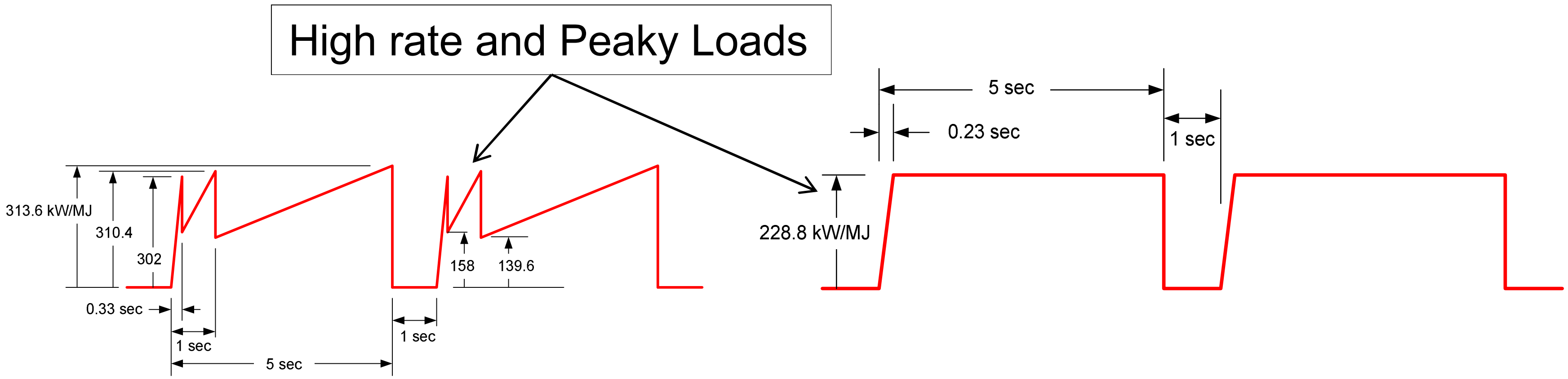
Photo # NH 96816 USS Archerfish off San Francisco, CA, 5 June 1945

The US Navy has over 100 years of history designing and operating shipboard microgrids.

The Challenge: Irregular Sources And Loads







The Solution

National Power & Energy

- Architecture
  - SmartGrid
  - HVDC Distribution
- Technologies
  - Alternative Energy Sources
  - Advanced Conductors
  - Hi-temp Superconductors
  - Energy Storage
  - Distributed intelligence & Smart Controls
  - Power Electronics
- Acceptance/Deployment
  - Regulatory Framework
  - Siting & Licensing

Military Power & Energy

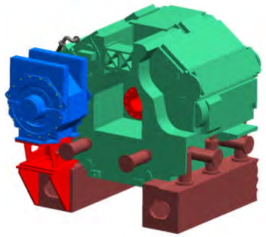
- Architecture
  - IPS
  - MVAC, MVHF, MVDC
- Technologies
  - Zonal Distribution
  - Power Generation Modules
  - Power Load Modules
  - Power Distribution Modules
  - Power Conversion Modules
  - Energy Storage Modules
  - Power Control Modules
- Acceptance/Deployment
  - Technology Insertion & Engineering Roadmap

For both Military and the National power and energy systems, the recognized solution is transformation

Courtesy of Mr. Jim Zgliczynski, General Atomics

Technology Approach

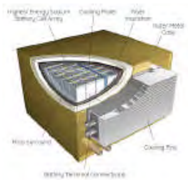
Advanced Generators With Improved SFC



“Hybrid” Generation and Propulsion Systems

High Efficiency Power Conversion and Electrical Architectures

Optimized Generator Loading



Energy Storage

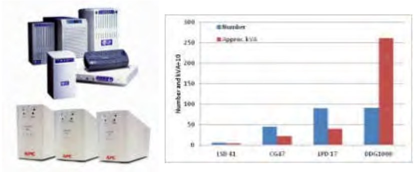
Energy Storage Is An Enabler For…

Electric Ships Office ESO Directing the Future of Ships Power

Current

Energy Surety

- Online storage devices for backup power
- UPS for protection of sensitive devices
- Closed, signature-free energy source

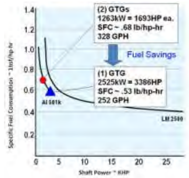


Increasing UPS and Batteries

Short Term

Fuel Savings

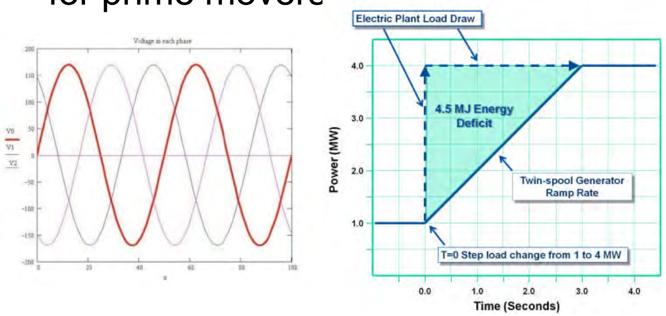
- Single Generator Operations (Shipwide UPS)
- Generator load optimization/scheduling
- Minimization of spinning assets
- Terrestrial distributions (microgrids)



Medium Term

Power Quality

- Advanced GTG Transient ridethrough
- Load changes outside of design space for prime movers

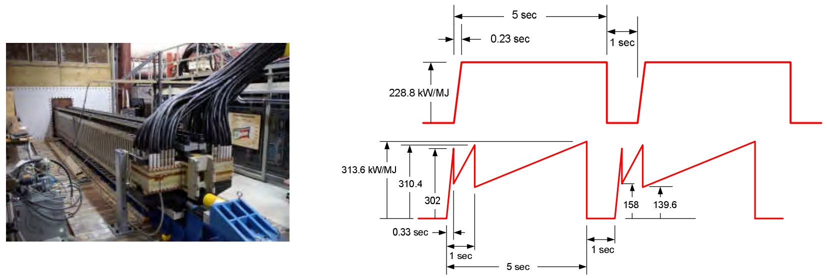


Power Quality Surety Under Two-Spool GTG Application

Long Term

Advanced Loads

- Pulsed applications
- Highly transient loads
- Cyclic load requirements



Potential EMRG Load Profiles

Partnering for Transformation…

GRIDS

- Flywheels
- Flow Batteries
- Compressed Air

ADEPT

- SiC power semiconductors
- GaN
- Advanced Capacitors
- Advanced magnetic materials
- DC Link converter

Electrofuels

- Direct Solar fuels

BEEST

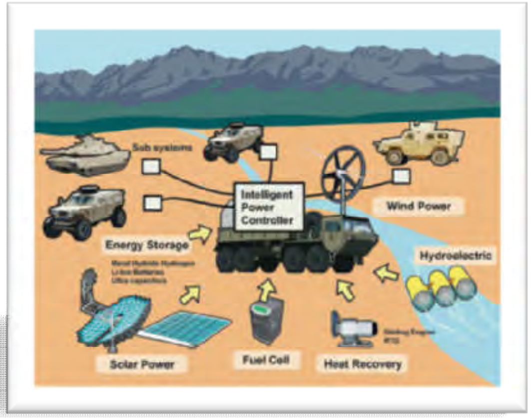
- Vehicle batteries

BEETIT

- Building cooling systems

IMPACCT

- Reducing CO_2 Emissions



Energy Security

- Alternative and renewable energy sources
- Future logistics tools
- Resilient power networks and systems

Efficient Power & Energy Systems

- Materials, devices and architectures to increase efficiency, and power density for platforms, and reduce weight for personal power
- Efficient power conversion, switching, distribution, control and thermal management
- Engines, motors, generators and actuators
- Electrochemical, thermal and kinetic energy storage

High Energy & Pulsed Power

- Energy storage power system architectures
- Energy pulsed power switching and control

DOD/DOE Collaborative Development → Military as Early Adopter → Technology Maturation → Cost Reduction → Commercial Deployment

Conclusions

- The cross between ever-growing electrical load and ever-increasing fuel costs presents a complex issue
- Technologies which can reduce consumption and provide greater power output require specific considerations to implement
- Smart architectures can support complex loads with enhanced efficiency
- Shipboard microgrid architectures have been under construction by the Navy for the last 100 years
- Coordinated approaches can enable commonality and commercial application to reduce cost

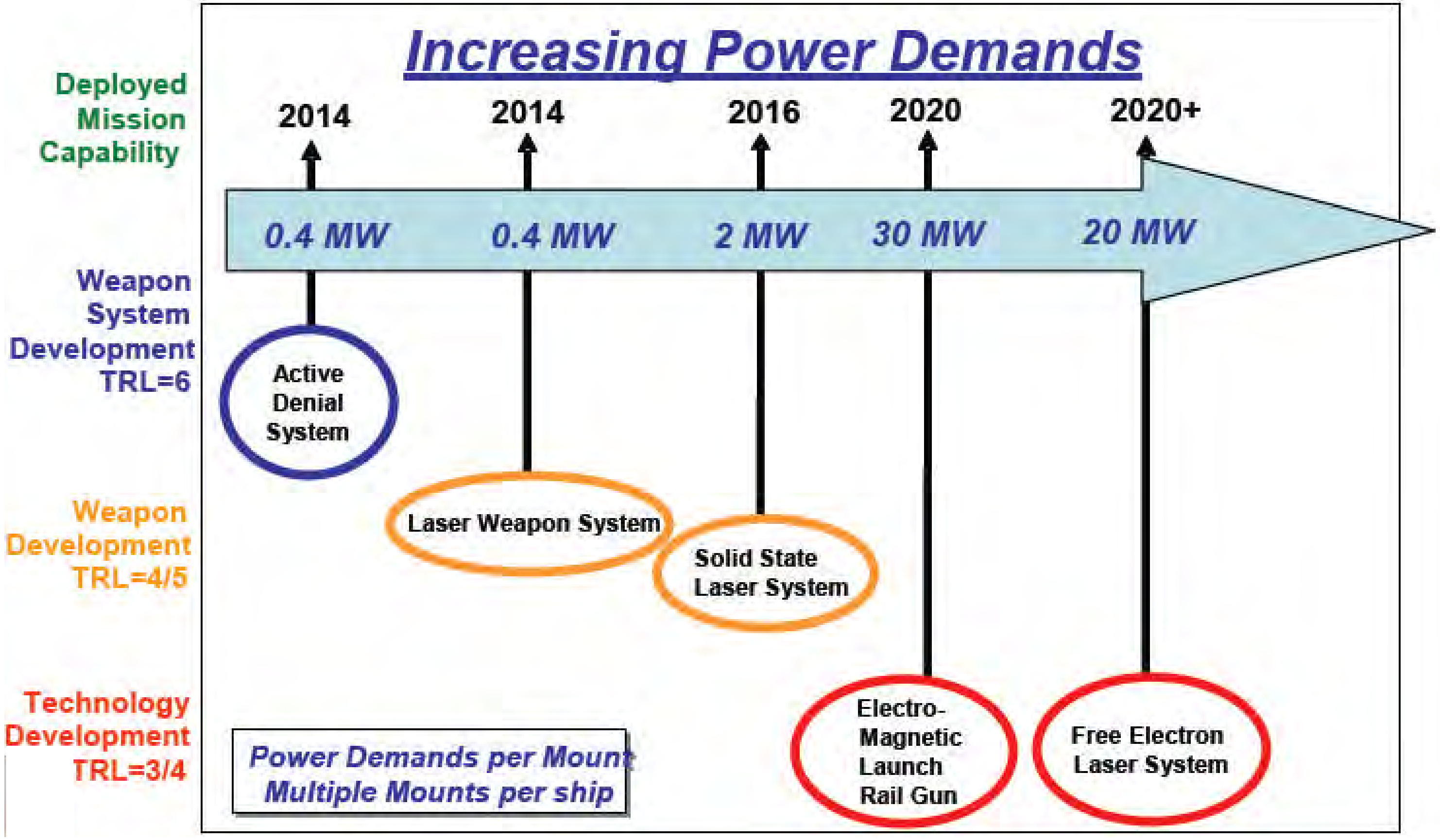
Acknowledgements

- Dr. Timothy McCoy, PMS 320
- Dr. John Pazik, ONR 331
- Mr. Dwight Alexander, Northrop Grumman
- Mr. Jim Zgliczynski, General Atomics
- Mr. John Heinzel, NSWCCD-SSES
- Mr. Donald Hoffman, ONR 331/NSWCCD-SSES
- Mr. John Kuseian, PMS 320/NSWCCD-SSES
- Mr. Nathan Spivey, PMS 320/NSWCCD-SSES

QUESTIONS?

BACK-UPS

Growing Sensor and Weapon Load Requirements



Balancing irregular loads with irregular sources (inconsistent and/or lagging transient response) presents a controls and architectural problem for both Shipboard and Terrestrial Microgrids.

US Navy Surface Fleet Energy Storage Vision

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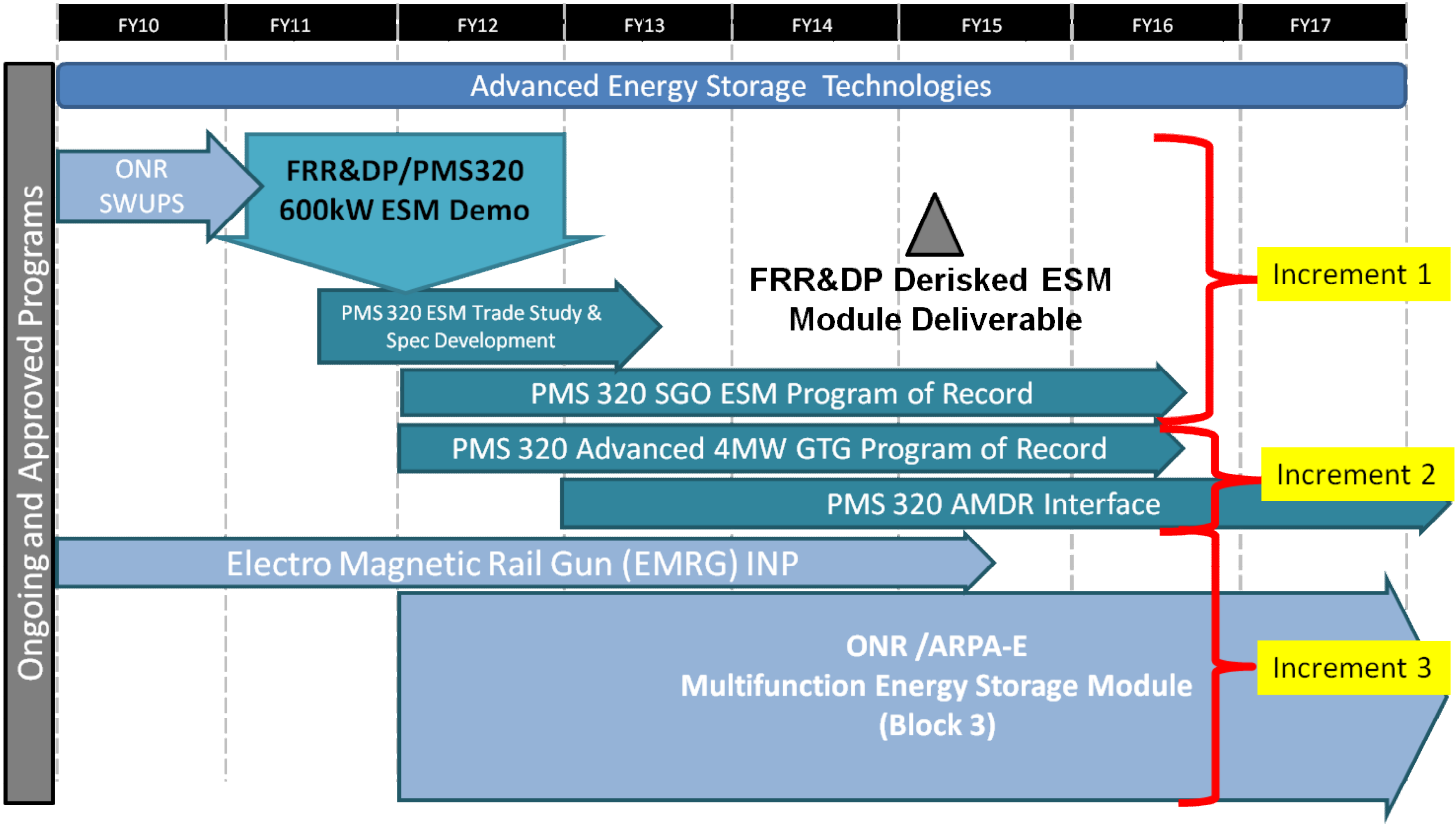

Fuel Cells and Hydrogen Energy

Power Expo

Ruth Cox
Fuel Cell and Hydrogen Energy Association
May 4, 2011

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LOGANEnergy
VERSA POWER SYSTEMS
GRAFTech International
SiGNa CHEMISTRY
Ceriumlabs BRINGING THE ELEMENTS TOGETHER

View in Washington

- **DOE Fuel cell and hydrogen programs are one of the most successful research, development and deployment plans ever.**
- **Misperception that fuel cells are not commercially ready – when in fact, several sectors are already in the market and growing.**

FCHEA's Focus:

- Get the Administration to embrace fuel cells of all kinds and hydrogen energy as integral components of the clean energy portfolio.
- Have that reflected in rhetoric, policies and purchasing behavior.
- New approach is gaining momentum and catching the attention of people in the right places.
- Gain the support in Congress, DoD and DOT in deployment of fuel cell and H2 energy systems

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TRANSFORMING THE ENERGY NETWORK

Fuel Cells and Hydrogen ARE Integral Components of the Clean Energy Portfolio

- **FC&HE enhance the performance of renewables**
  - Solar and wind are intermittent; FC&HE can accelerate the return on solar and wind investments with transformation and storage
  - Biomass – it's a dirty business and we can clean it up
  - Biofuels – increased efficiency; lower pollution
- **FC&HE enhance performance and lower the negative environmental impacts of fossil fuels**
  - Efficient use of finite domestic energy sources
  - CO2 separation and virtually ZERO criteria pollutants
  - Can even work with coal and jet fuel!!
- **Distributed generation is the most efficient and reliable way to deliver power**
- **FCEV's crucial to reaching energy goals**
  - FCEVS are technologically ready
  - Best option for medium-large size vehicles
  - H2 infrastructure required for commercial rollout

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Commercially Deployed TODAY!

- **Refrigeration, prime power, back-up power**
  - Price Chopper/Whole Foods/Central Grocers
  - AT&T, Sprint, Verizon, US Military
- **Large corporations**
  - Google/eBay/Staples/Coca-Cola/FedEx/Walmart
- **Renewable solutions**
  - Sierra Nevada/Fosters/Sapporo/Kirin/Gills Onions
  - Wastewater treatment plants/landfills
- **Hotels across the country**
  - Sheraton/Hilton/Hyatt/Westin Hotels
- **Research and Data Banks**
  - University Campuses in Connecticut and throughout California

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DOE

U.S. DEPARTMENT OF ENERGY

- Recovery Act funding ($43 million) will deploy up to 1,000 fuel cells for early market applications
  - Materials Handling and Telecom Back-up Power deployments
- Waste to Energy Programs
- Technology validation projects - data collection and operation of backup power systems and specialty vehicles
- Collaboration with DOT on the Fuel Cell Bus Program will continue; and CHHP demonstration (with CaFCP and SCAQMD)
- Funding opportunities for residential stationary fuel cells, CHHP fuel cell systems and APUs for aircraft and heavy duty trucks

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Demonstrations Underway

- CHHP in Fountain Valley, CA
- Portable and auxiliary power in the military, aviation and trucking industry
- Propulsion for unmanned vehicles
- Fuel cell buses and vehicles in CA and HI
  - Partnership in HI noteworthy for involving the natural gas utilities
- Grid applications

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DoD Hydrogen and Fuel Cell R&D

- **Hydrogen Research**
  - **$18M in FY10 (primarily congressionally funded efforts)**
    - Biocatalysts for H2 production
    - Reformation of logistics fuels
- **Fuel Cell Research & Demonstration**
  - **~$35M in FY10**
    - Basic and applied research in catalysts and materials (~1/3 congressionally funded)
    - Unmanned systems, deployable field units and man portable applications

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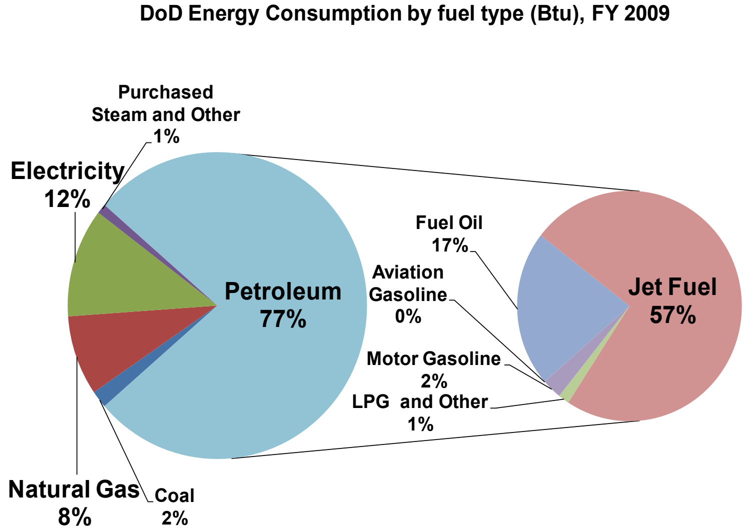
DoD-Energy

- **DoD is the nation's largest energy consumer**



Source: http://www.eia.gov/aer/pdf/pages/sec1_29.pdf

- Facilities energy cost $4 billion in FY 2009
- Many directives, mandates, goals and targets

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DoD Commercial Roll-out Program

FC AND H2 applications with near-term commercial potential

- Distributed Stationary Power
- Back-up Power
- Non-tactical Material Handling and Ground Support Equipment (MHE/GSE)
- Portable Power for Tactical Operations
- Unmanned Air, Ground and Underwater Vehicles (UXVs)

Other applications of interest to DoD

- Soldier Wearable and Portable Power
- Remote Sensors and Surveillance
- Auxiliary Power Units for Ground Vehicles, Ships and Aircraft
- Non-tactical Light Duty Vehicles
- Mobile Electric Power (MEP)
- Power for Ships
- Non-tactical Personnel Transport (Buses)

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Distributed Stationary

DoD Market Characteristics

- Over 500,000 buildings at 5,000 sites
- Facilities account for 30% of DoD's energy costs
- Prime Opportunities for Combined Heat and Power (CHP)
- Mission-critical needs for uninterruptible power
- Little knowledge of fuel cells and potential benefits.

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Distributed Stationary Power

- **<u>Fuel Cells at DoD Installations</u>**
  - Camp Pendleton, CA
  - MCAGCC, 29 Palms, CA
  - Camp Parks, CA
  - Naval Sub Base, Groton, CT
  - PMRF, Kauai, HI

- **<u>A Growing Private Sector Market</u>**
  - UTC Power PAFCs
  - FuelCell Energy MCFCs
  - BloomEnergy SOFCs

- Market supported by government subsidies

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Distributed Stationary Power

<u>Value Proposition</u>

- **Benefits**
  - Reliable, grid-independent power for critical needs
  - Higher efficiency = Lower energy costs
  - Scalability
  - Reduced pollutants and GHG
  - Compliance with legislation and EOs
  - Quiet

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Backup Power

DoD Market Characteristics

- 1,000's of DoD facilities with mission-critical needs for continuous power.
- Missions with critical power needs have increased.
- DSB concluded military installations too dependent on vulnerable grid; back-up power is inadequate.
- Little knowledge of fuel cells and potential benefits.

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Backup Power

- **<u>Fuel Cells at DoD Installations</u>**
  - Fort Jackson, SC (Zero outages/102 hours saved)
  - Los Alamitos Joint Training Base, CA
  - Marine Corps Logistics Base, Barstow, CA
  - Air National Guard Sites, HI
  - Army CERL Projects

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Backup Power

A Growing Private Sector Market

- Sprint Nextel
- AT&T
- PG&E
- Metro PCS, FL

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Backup Power

Value Proposition

- **Benefits**
  - Longer system life than alternatives
  - Lower maintenance requirements
  - Reduced emissions, including GHG
  - Reduced noise

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Materials Handling/Ground Support

DoD Market Characteristics

- Tens of thousands of units in DoD inventory
- Currently use batteries, propane, diesel fuel and gasoline
- Validation Programs advancing commercial readiness of fuel cells and hydrogen

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Materials Handling/Ground Support

- **Fuel Cells at DoD Installations**
  - DLA Distribution Center, Susquehanna, PA
  - DLA Distribution Depot, Warner Robins, GA
  - DLA Distribution San Joaquin, CA
  - Hickam Air Force Base, HI

- **A Growing Private Sector Market**
  - Sysco Distribution Center, TX
  - FedEx Service Center, MO
  - GENCO Distribution Centers
  - Central Grocers' Distribution, IL
  - Whole Food
  - Price Chopper

Forkliftfueling - a Plug Power forklift

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Materials Handling/Ground Support

Value Proposition

- **Benefits**
  - Improved productivity
  - Lower O&M costs
  - Reduced emissions and noise
  - Lower costs
  - Smaller footprint
  - Environmental

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Soldier Power

Issue

- Sharp rise in Soldier worn capability has resulted in a dramatic increase in the numbers and variety of batteries carried by the war fighter—added weight.
- This trend is unsustainable from a Soldier load and logistical perspective.
- Load injuries sharply on the rise

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Nett Warrior Power Excursions

Worn Power

Conformal Batteries

Increase Energy Density

Ergonomic

Portable Charging

Fuel Cells

Renewable Energy

Portable Charging

Unit Charging

Universal Chargers

Soldier Load

Mobile Power

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Soldier Power

Message to Industry

- Safely increase energy density of current and emerging tech.
- Reduce size and weight of soldier-worn power
- Integrate capabilities to reduce load and complexity
- Improve system efficiency and reduce the logistical burden to the war-fighter

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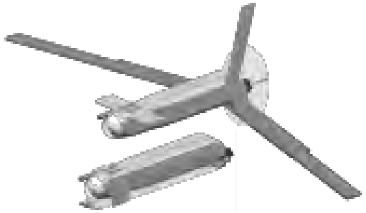
UAV

Objective: To provide advanced electrochemical devices, including fuel cells, to enhance the capability of the warfighter.

- Persistent Wearable Power: Micro Air Vehicles (< 1 lb)
  - 10's to 100's of Watts

- Squad/Fire-Team Support: Hand-Launched/Air-Dropped (Target: < 20 lbs)
  - 10's to 100's of Watts

- Persistence UAS/Strike Capable : Ground-Launched/Air-Dropped (Target 50 – 150 lbs)
  - 1000's of Watts



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UAV

Objective: To provide advanced electrochemical devices, including fuel cells, to enhance the capability of the warfighter.

- DLA/Naval Surface Warfare Center, Crane Division
  - Protonix
- TARDEC
  - Adaptive Materials
- Naval Air Weapons Station, China Lake
  - Adaptive Materials

Fuel Cell & Hydrogen Energy Association
TRANSFORMING THE ENERGY NETWORK

Recommendations for DoD

- FC systems should be considered for providing power, heat and cooling for new and current installations
- Monitor and evaluate new FC systems development
- Develop power purchase agreement models that enhance ability to efficiently acquire FC systems
- Improve ability to realize benefits of third party financing
- Expand field testing of soldier and UMV power
- Support development and demonstration projects with R&D funds.

Thank You

Contact Us

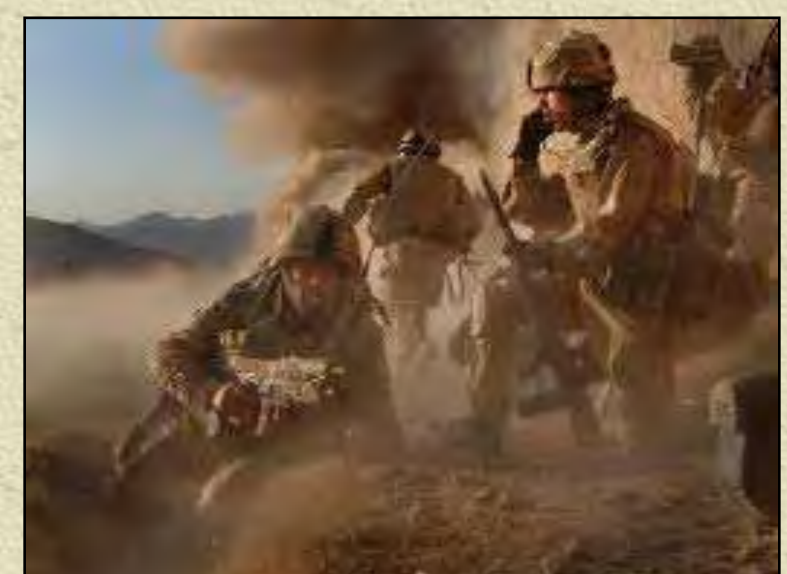
Ruth Cox
Executive Director
202-736-5735
rcox@fchea.org

www.fchea.org

Fuel Cell & Hydrogen Energy Association
TRANSFORMING THE ENERGY NETWORK

WWW.NESTENERGYSERVICES.COM

The Alternative Energy Coalition: A Struggle for Power in the Expeditionary Environment



Tom Lederle, VP
Product Development

THE CHALLENGE

REDUCE RISKS TO WARFIGHTERS

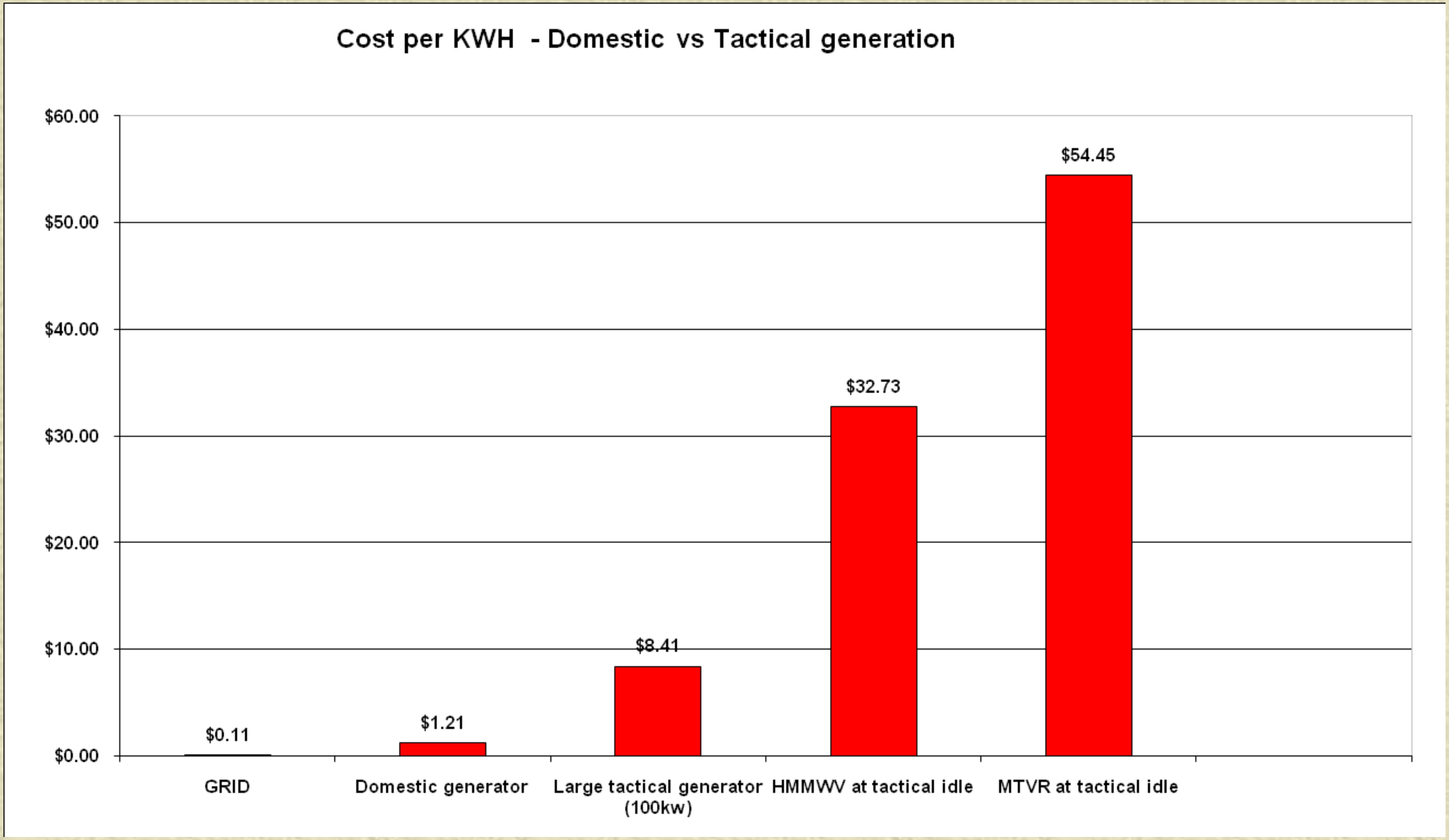
REDUCE FUEL CONSUMPTION

Marine Commandant General James F. Amos:

(Excerpt from the General's comments on March 1, 2011 before the House Armed Services Committee)

"The Marine Corps is leading the development of expeditionary energy solutions …. reducing energy demand in our platforms and systems, increasing the use of renewable energy, and instilling an <u>ethos of energy and water efficiency in every Marine.</u> Our priority is force protection — saving lives by reducing the number of Marines at risk on the road hauling fuel and water."

DOLLAR COST OF TACTICAL GENERATORS



Assumes fully burdened cost of fuel

Assumes 33% typical load factor

Disregards maintenance and depreciation

THE HUNT

EXFOB EVALUATORS LOOK FOR ALTERNATIVE-ENERGY SOLUTIONS

✓That are light-weight, portable

✓That will endure harsh climates

✓That will stand up to rough handling

✓That ensure electrical power off-grid

✓That are easy to set up by a small team under stress

✓That reduce fuel consumption

MARINE EXFOB EVALUATIONS

MAR 2010

QUANTICO

29 PALMS

AUG 2010

NEST ENERGY AT EXFOBS - 2010

QUANTICO

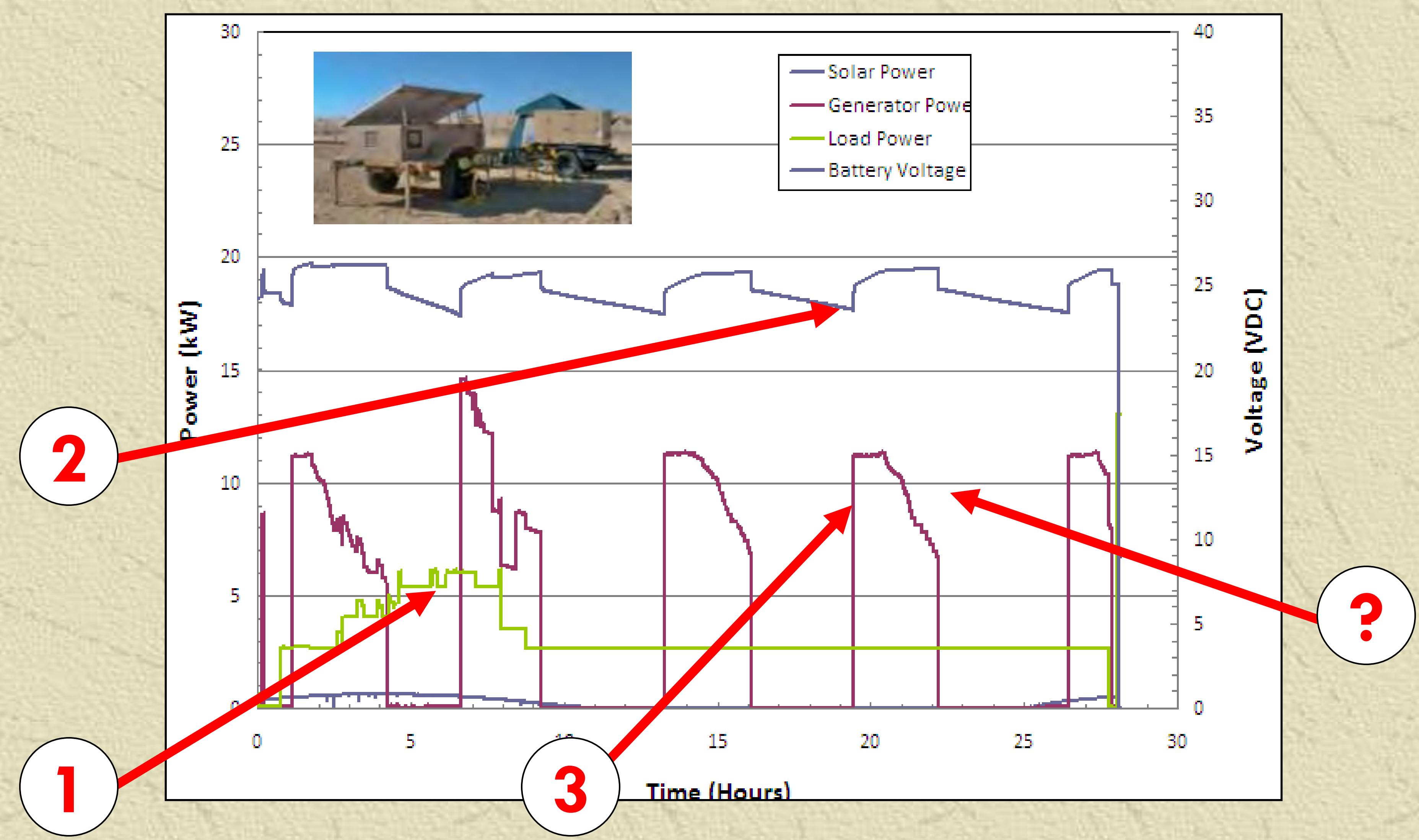
29PALMS

MARCH

AUGUST

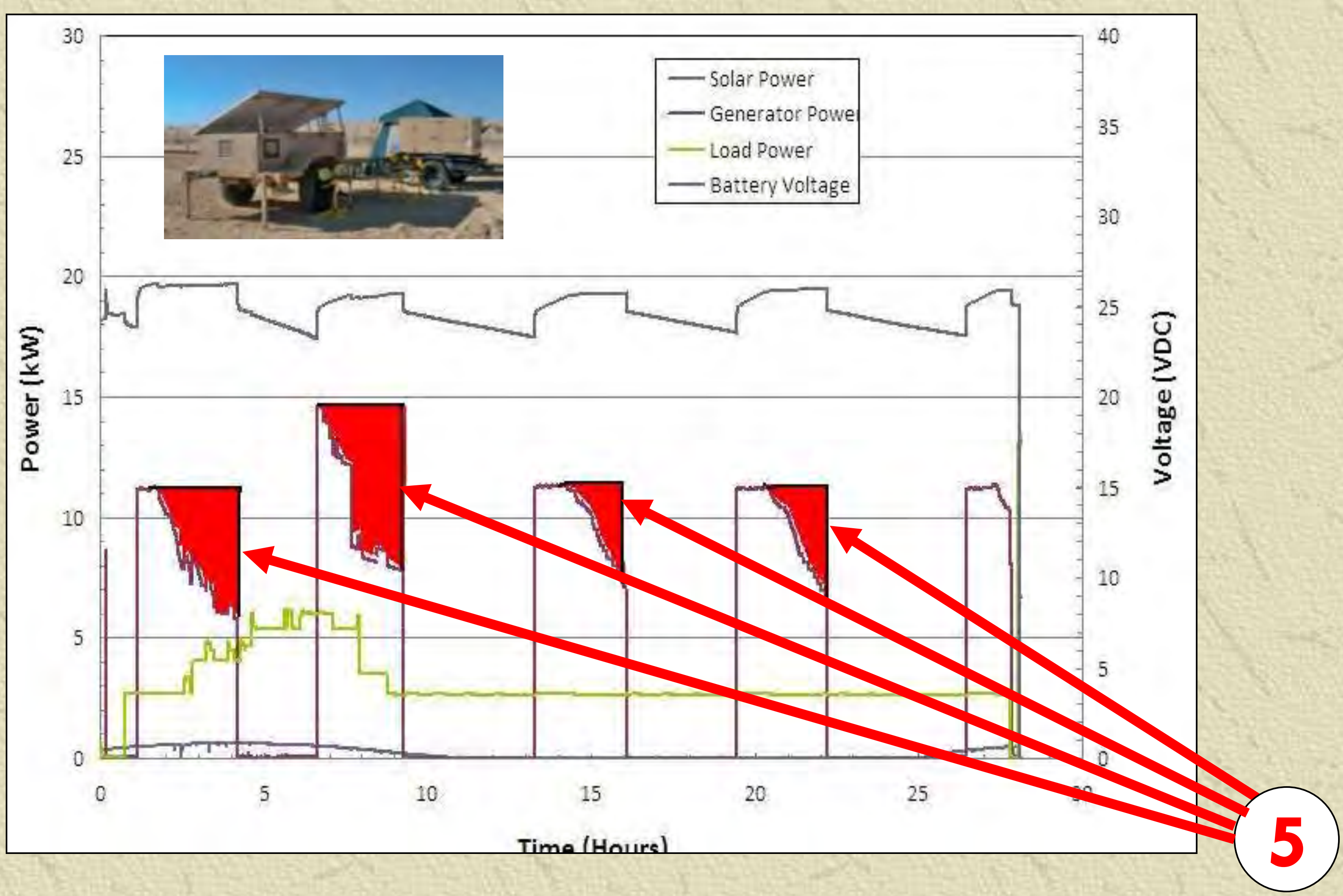
ONR DATASET FROM EXFOB4 / 29PALMS

Eagle Hybrid Power Trailer – AGM Batteries



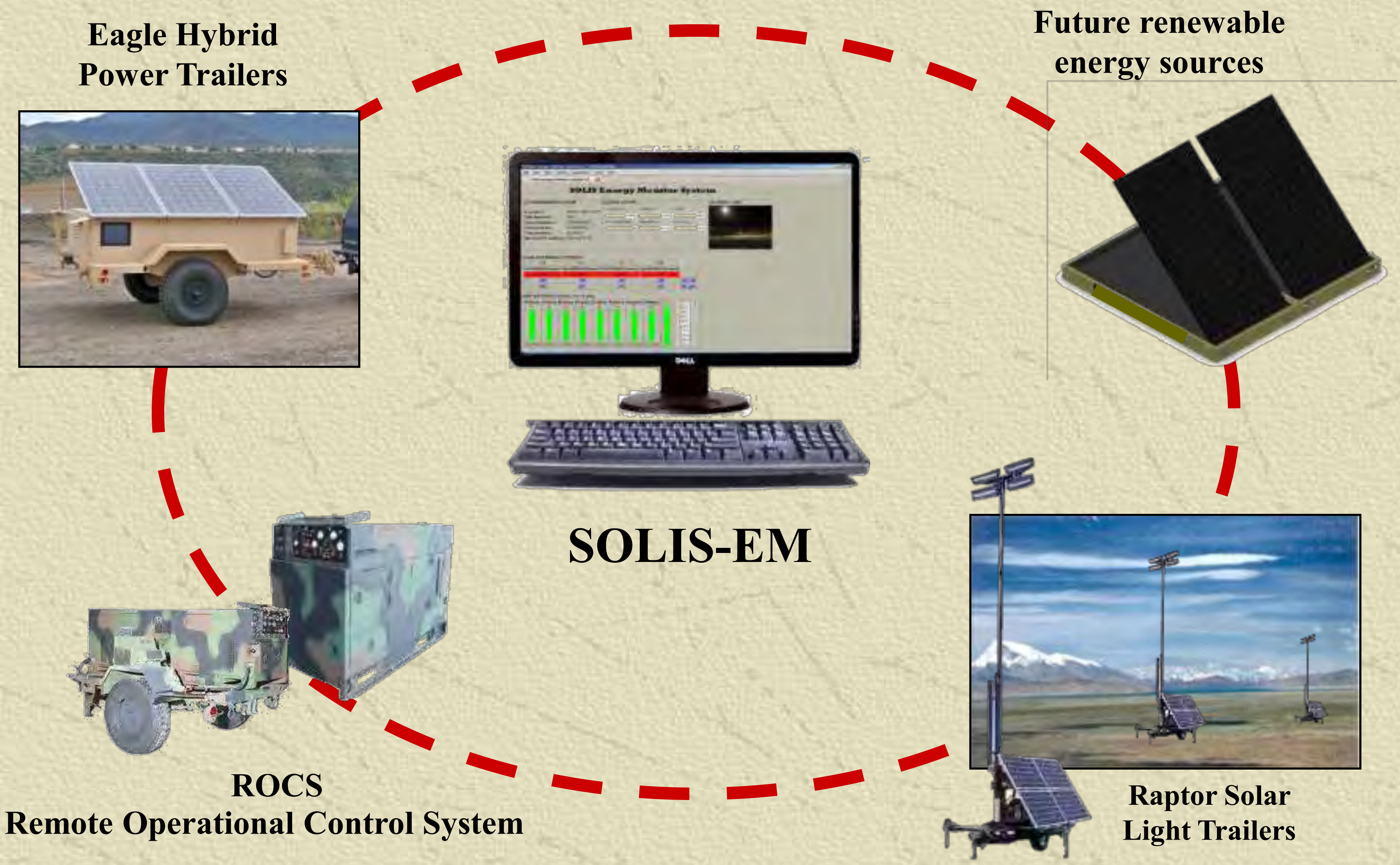
ONR DATASET FROM EXFOB4 / 29PALMS

Eagle Hybrid Power Trailer – LiFePO Batteries



THE MASTERMIND

A —SYSTEM OF SYSTEMS”



SOLIS ENERGY MANAGEMENT & CONTROL

Cell

FOB

Command

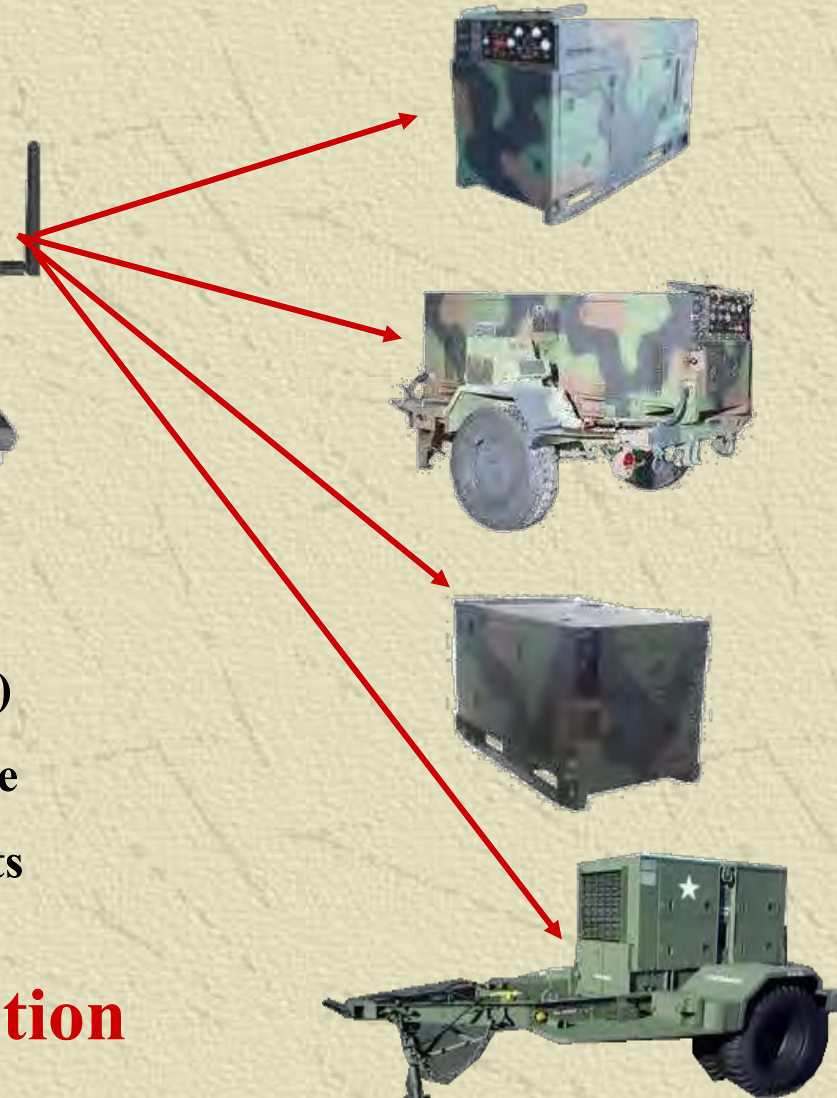
Field

- Monitors fuel/battery status
- Alerts to potential problems
- Secure "extranet" data transmission
- Manages fossil & renewable resources
- Climate database helps predict fuel use
- Controls multiple resources simultaneously

✓ **Reduces fuel consumption**

REMOTE OPERATIONAL CONTROL SYSTEM

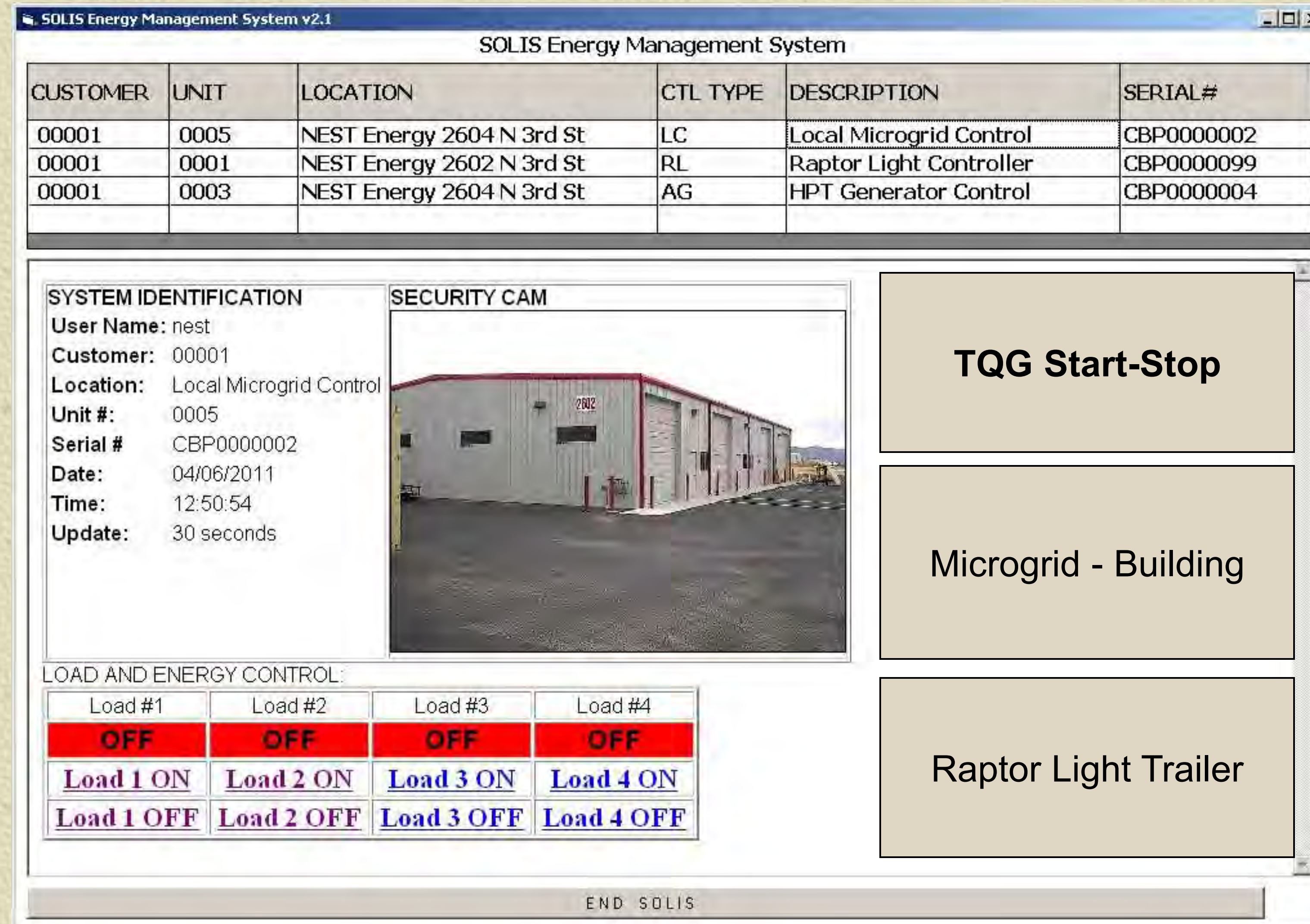
ROCS



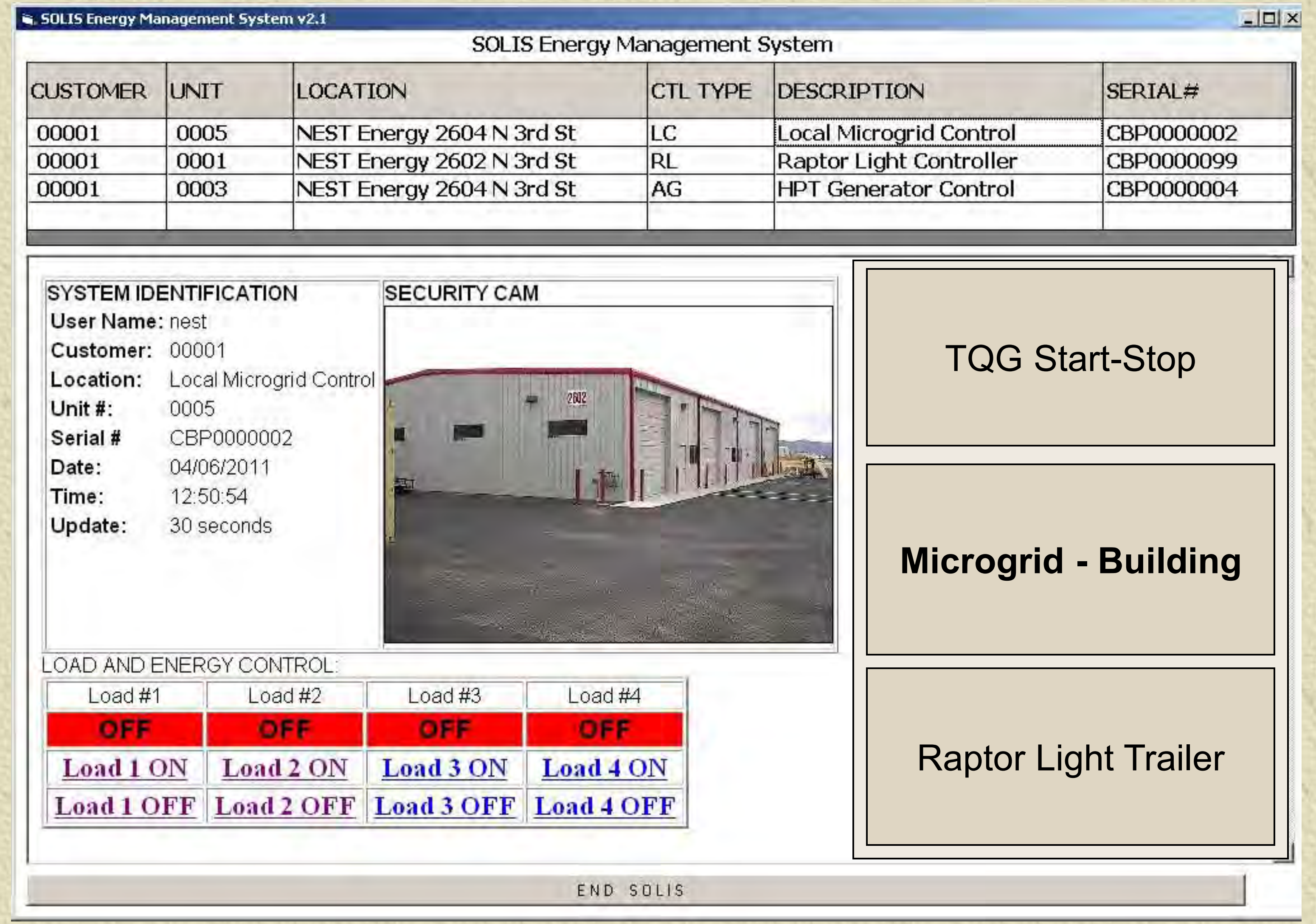
- Generator management
- Compatible with TQG —family
- Local or remote access (Internet)
- Simple operation, field installable
- Controls up to 256 tactical gensets

✓ **Reduces fuel consumption**

SYSTEM OF SYSTEMS DEMO



SYSTEM OF SYSTEMS DEMO



SYSTEM OF SYSTEMS DEMO

SOLIS Energy Management System v2.1

SOLIS Energy Management System

CUSTOMER	UNIT	LOCATION	CTL TYPE	DESCRIPTION	SERIAL#
00001	0005	NEST Energy 2604 N 3rd St	LC	Local Microgrid Control	CBP0000002
00001	0001	NEST Energy 2602 N 3rd St	RL	Raptor Light Controller	CBP0000099
00001	0003	NEST Energy 2604 N 3rd St	AG	HPT Generator Control	CBP0000004

SYSTEM IDENTIFICATION

User Name: nest
Customer: 00001
Location: Local Microgrid Control
Unit #: 0005
Serial # CBP0000002
Date: 04/06/2011
Time: 12:50:54
Update: 30 seconds

SECURITY CAM

LOAD AND ENERGY CONTROL:

Load #1	Load #2	Load #3	Load #4
OFF	OFF	OFF	OFF
Load 1 ON	Load 2 ON	Load 3 ON	Load 4 ON
Load 1 OFF	Load 2 OFF	Load 3 OFF	Load 4 OFF

TQG Start-Stop

Microgrid - Building

Raptor Light Trailer

END SOLIS

A CLOSER EXAMINATION…

EAGLE HPT-T (TACTICAL)

- Supports 10kw peak load
- Cuts attached genset run time by 50%
- Easy to set up, —plug & play”
- Towable—weight under 4200#
- Manages genset from local or remote

✓ **Reduces fuel consumption**

EAGLE HPT-G (GENERATOR ONBOARD)

- **Lithium battery pack**
- **Supports 10kw peak load**
- **Supports 3kw average load for about a week**
- **Towable—weight under 4200#**
- **Controls onboard genset automatically**
- **Integrated SOLIS Energy Management**

✓ Reduces fuel consumption

RAPTOR SOLAR LIGHT TRAILER

- Zero maintenance
- 12-hour nighttime illumination
- 100% solar, uses no fossil fuel
- Complete automatic operation
- Easy to set up, —plug & play”
- Inverter for plug-in items

✓**Reduces fuel consumption**

TEREX | FUCHS

NEST ENERGY

	Terex AL4000	NEST Raptor
Purchase price	$8,900.00	
		$17,609.19
Fuel cost, annual	$86,724.00	$0.00
Maintenance, annual	$13,140.00	
Battery pack, every three years, annualized cost		$1,066.67
Total annual cost of operation	$99,864.00	$1,066.67
Total 3-Year Cost of Operation	**$308,492.00**	**$20,809.19**

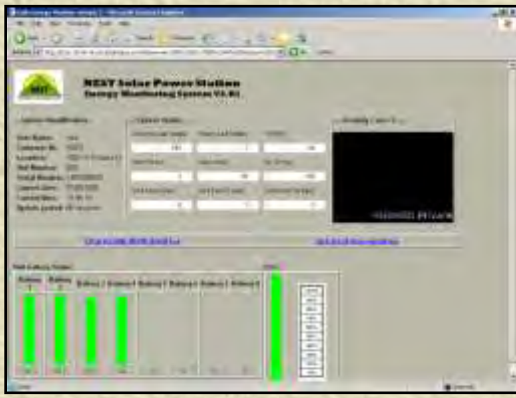
RAPTOR SOLAR LIGHT TRAILERS, POST EXFOB

EAGLE HPT, POST EXFOB

NEXTFOB


THE MARINE CORPS
AIR GROUND COMBAT
CENTER
TWENTYNINE PALMS
CURRENT TEMP: 120°

EAGLE HPT-EM (EXTENDED MISSION)



- **Supports 3kw missions for 15 days**
- **Lithium battery pack (U.S. MADE)**
- **NEST super-light solar panels**
- **Handles 10kw peak load**
- **Towable—weight under 4200#**
- **Controls <u>onboard</u> genset automatically**
- **Integrated SOLIS Energy Management**

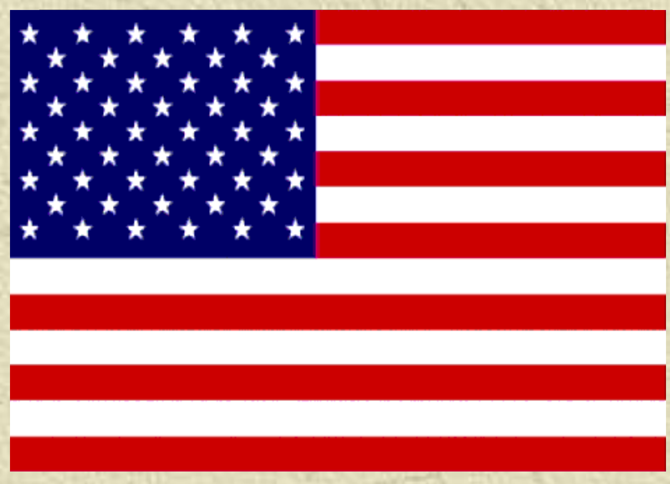
✓ **Reduces fuel consumption**

VEHICLE INTEGRATED POWER UNIT REGULATOR

- Mounts to tactical vehicles
- Three models - support 1.5 to 4kw peak load
- Reduces vehicle idle time by 50%
- Automatic engine start/stop
- Simple field installation
- Supports 12 or 24v battery systems

✓ **Reduces fuel consumption**

EXFOB = WIN-WIN



REDUCE FUEL CONSUMPTION

REDUCE RISKS TO WARFIGHTERS

NEST Energy has alternative energy-based systems—in production-- that will reduce risks Marines and other branches of service face hauling and guarding fuel supplies in expeditionary environments.




They're ready now.

Nest Energy Services LLC
2602 N. Third St. Unit B
Prescott Valley, AZ 86314
Toll-free: 877-640-4701

WWW.NESTENERGYSERVICES.COM

EARL ENERGY

2011 Joint Service Power Expo
Session 22: Hybrid Systems

The Power to Sustain Warfighter Dominance

Optimizing Generator Efficiency with Energy Storage Technologies

Presented by

Doug Moorehead
President, Earl Energy

Earl Energy Overview

- Earl Energy is an energy systems engineering and product development firm, owned and led by veterans and headquartered in Portsmouth, VA
- We design, build, test, install, and service military power generation and energy management systems
- Affiliated with Earl Industries, a diversified industrial defense contractor with 900 employees and a global footprint
- 15 years of shipboard electrical power and control systems experience
- Expertise in electrical control panels, switchboards, power distribution, and full-scale automation systems
- Preferred power and controls vendor for Military Sealift Command

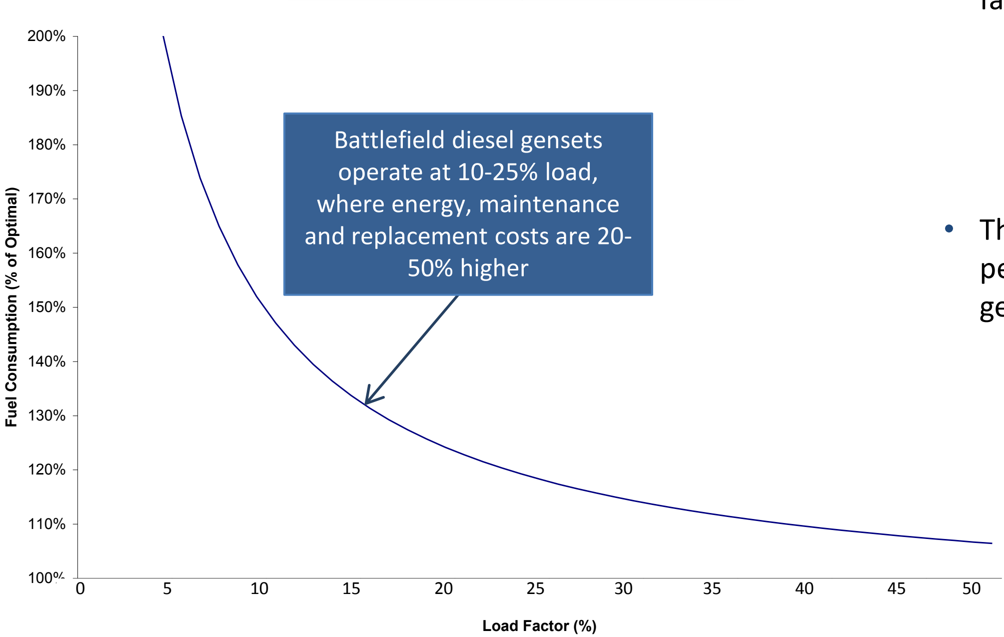
Doug Moorehead, President and Principal Investigator

- Director of Automotive and Grid-Level Energy Storage at A123 Systems, Inc.
- Original patent holder of A123 Systems, Inc. founding intellectual property
- Bachelor of Science, United States Naval Academy
- Master of Science in Materials and Engineering, Massachusetts Institute of Technology
- Master of Business Administration, Harvard Business School
- U.S. Navy SEAL, 9 years, Combat Veteran

EARL ENERGY

Generator Inefficiency & the Hybridization Solution

Diesel Fuel Consumption (Source: EPA)



- Battlefield diesel generators typically operate at low load factors, resulting in ***exponentially*** higher:
  - Fuel consumption
  - Maintenance costs
  - Physical depreciation of the generator
  - Hazardous emissions of NOx, SOx, PM, and GHGs
- Through plug-and-play integration of small, high-performance energy storage systems, existing battlefield generators can be hybridized
  - Reduces generator runtime by 60-90%, with corresponding reduction in fuel consumption, maintenance and MTBF
  - Maintains 100% power reliability
  - Improves power quality
  - Increases overall sustainability of existing genset inventory and deployed power systems

Earl Energy

Earl Energy FlexGen Development Roadmap

Capabilities

- 18kW rated power
- 3x 120VAC, 3-phase outputs
- 5kW integrated PV
- AC & 3x DC inputs
- Integrated energy storage
- Dynamic load mgmt/shedding
- Automatic genset start/stop

EARLCON

Initial USMC Testing Aug 2010 → **USMC Operational Testing May 2011** → **Deployment to Afghanistan July 2011**

- 3kW rated power
- Integrated lithium ion energy storage
- AC & 3x DC inputs
- Automatic genset start/stop
- Man-portable

FlexGen 3kW

Lithium ion Prototype May 2011 → **USMC Operational Testing Aug 2011**

- 35, 60 and 100kW rated power
- 2x AC & 3x DC inputs
- Integrated lithium ion energy storage
- Automatic 2x input genset paralleling/phase matching
- Automatic genset start/stop

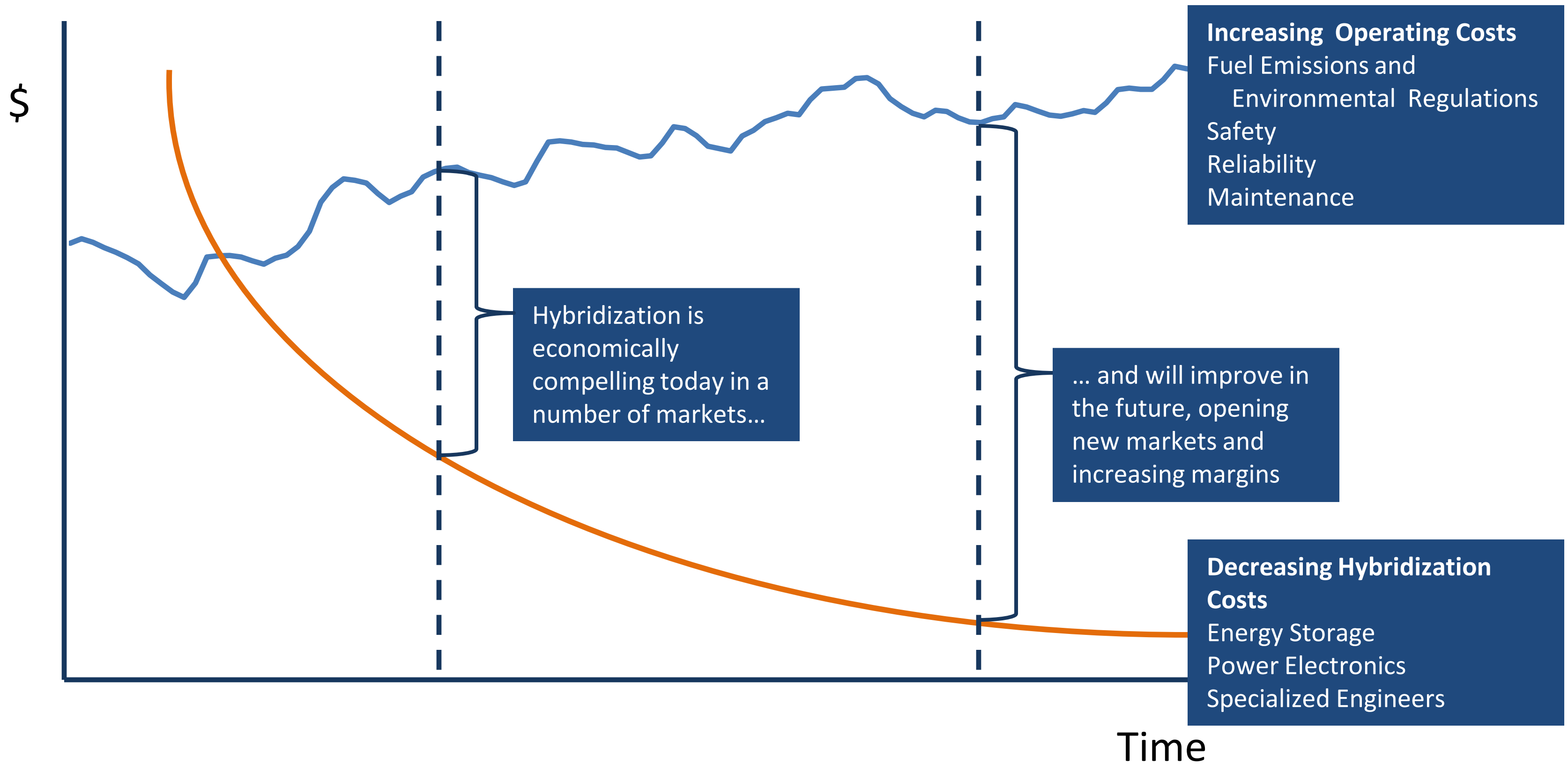
FlexGen 35kW 60kW 100kW

Prototype Aug 2011 → **DHS Unit Sep 2011**

EARL ENERGY

Why Now?

- Energy storage and large-scale power conversion technology have benefitted from 5+ years of significant government and private investment resulting in lower costs and improved performance, reliability, and safety
- In a number of large markets, the costs of hybridization are now competitive economically with traditional power systems



Business Case Analysis

- 5kW EARLCON with integrated energy storage participated in Aug 2010 ExFOB Phase IV in Twentynine Palms, CA
  - NSWC test results confirmed 93% reduction in fuel consumption of 6kW generator
  - Excluding renewable power sources, hybridization of generator alone reduced fuel consumption by 60%
- USMC MARCORSYSCOM issued sole source contract for 2x EARLCONs in Feb 2011 to power battalion-level Combat Operations Centers (COC)

- FlexGen generator hybridization of a 3kW Tactical Quiet Generator (TQG) delivers a cash payback period of 4-5 months and total savings of $68,000 over the 9-year life of the system
- Enables the TQG to turn off for 20-21 hours per day
- Reduces maintenance, emissions, sound, and vibration by ~80%
- Extends generator replacement cycle by 4x to approximately 5 years
- Our financial analysis excludes the positive financial and competitive impacts of the reductions in emissions, sound, and vibration
- The primary drivers of payback are electrical load profile, fuel consumption, and fuel cost

Key Assumptions

- Genset price: $10,400; no salvage value
- Genset lifecycle: 10,000 hours
- Genset annual maintenance: $2,500
- 24/365 operation
- Diesel fuel cost: $7.50-$30/gal
- Hybridization system lifecycle: 9 years
- Battery service: 18 months

Example - 3kW TQG at $7.50 ADP			
Annual Generator Power Output		4,011	kWh
Cost of Power at Optimal Power Factor	$	1.95	
Annual Cost of Power at Optimal Power Factor	$	7,828	
Actual Cost per kWh (incl. fuel & maint.)	$	5.28	
Observed Annual Cost of Power	$	21,168	
Annual Cost of Generator Inefficiency	$	13,340	
Production Cost of 3kW Hybridization System	$	5,750	
Payback period (months)		5.2	

EARL ENERGY

Off-Grid Markets & Sales

- The market for generator hybridization is large, spanning multiple customer segments, identified by the following characteristics:

High fuel delivery costs – battlefield, remote locations, at sea

High maintenance costs – dangerous, harsh or remote locations, at sea, highly technical equipment, mission-oriented power systems

High generator utilization rates – where gensets provide prime power, where engineers factor in excess capacity as a rule

Emissions restrictions/incentives – European markets tax carbon emissions, in-port vessels, harbor dredging

Silent and low vibration power – military operational security, luxury yachts, highly instrumented equipment

Clean, high quality power – sensitive instrumentation

Mission-critical power – uninterruptible power supplies

Inform
Energy surveys
Identify/quantify inefficiencies
Collect configuration data

Reliability
Put products in customers' hands
Flawless field service/support

Endorsement
Third party validation
Ports, EPA, IMO, NGOs

Measure
Prove business case
Improve product design

Thank You

Doug Moorehead
dmoorehead@earlenergy.com
www.earlenergy.com

EARL ENERGY

JSPE

"Small-Scale Hybrid Power Systems"

Joint Service Power Expo
5 May 2011

Al Zaccor, COL (USA-Ret.)
CEO, Solar Stik™

OUTLINE

- Definition of a Renewable Energy Power System
- Principles of System Design
- Continuous vs. Stored Power Models
- Elements of a Hybrid System
- CRADA Project w/ PM-MEP

Definition

A system comprised of one or more renewable energy inputs, associated power management, storage and distribution components, and the interface to users' applications.

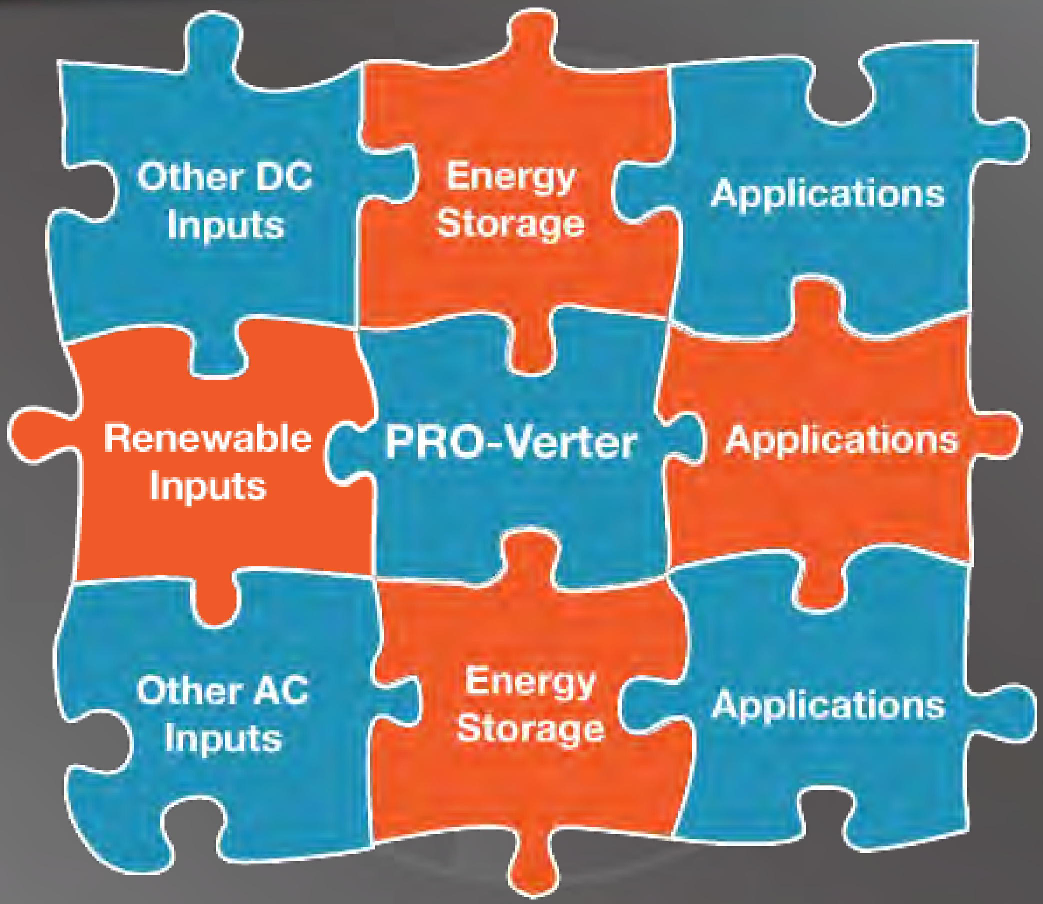
Principles of System Design

- Scale
- Modularity or Open Architecture
- Power Management Focus
- Efficient Applications

Scale

- FOB vs. COP
- Production
- Power Management Capacity
- Power Distribution Mode

Open Architecture



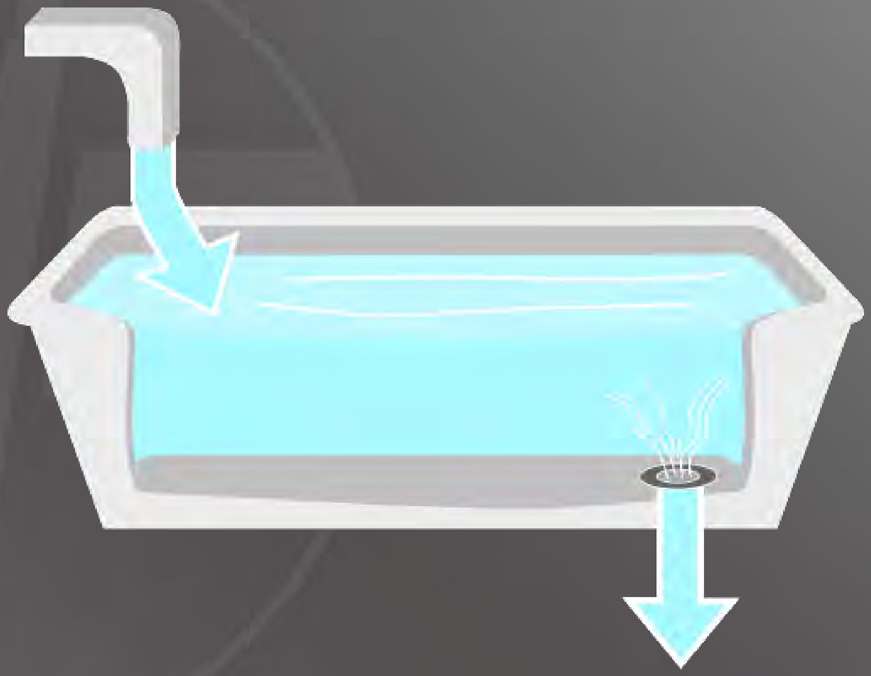
Power Management Focus

- Solar Charge Controls
- Integrated Multiple Inputs to Energy Storage
- Inverter/Charger Capabilities
- Programmable User Interfaces
- Power Distribution Modes

Efficient Appliances

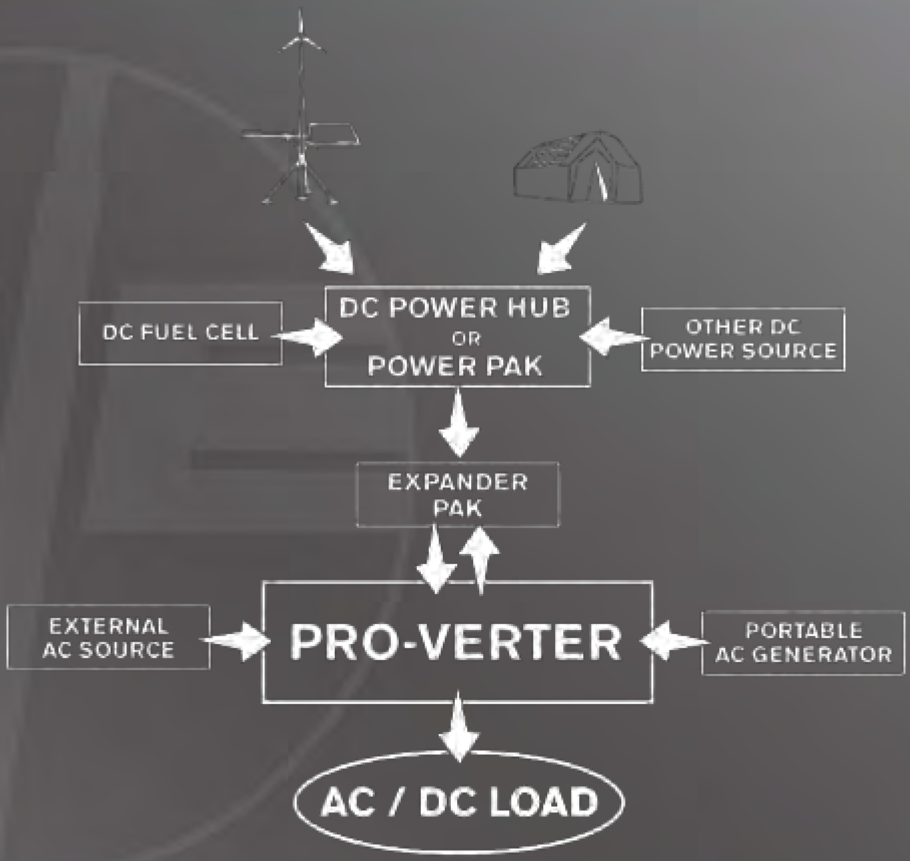
Continuous Power Operations

- Cultural Challenge
- Balancing Inputs and Outputs
- Calculating and Using Power "Budgets"
- Hybrid Systems Bridge the Gap
- Efficiency Trends



Hybrid System Elements

- Renewable Energy Inputs
- Conventional Energy Inputs
- Other Inputs
- Power Management
- Energy Storage
- AC Power Distribution
- DC Power Distribution
- Applications



Small Scale Microgrid

CRADA with PM-MEP

Objective: To develop a comprehensive, user-friendly technical solution that enables a conventional fuel-powered US Army tactical generator set to operate…with a connected renewable energy (solar and wind) powered generator(s) in ***a seamless, automated fashion*** for the purposes of ***reducing fuel consumption and run time of the conventional generator.***

Key Components

- Renewable Energy Systems
- Energy Storage
- 3kW TQG MEP-831A
- Modification Kit
- PRO-Verter 3000 APM AGS

PRO-VERTER 3000 APM AGS

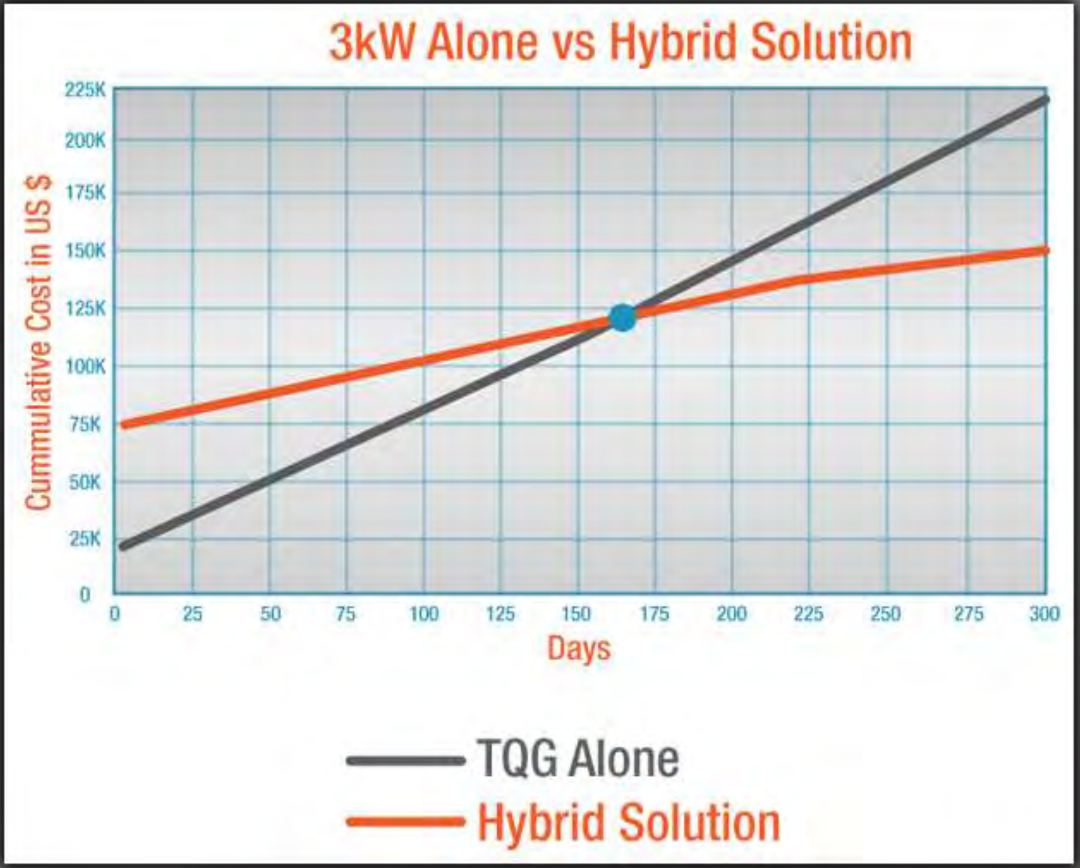
POWER ON THE MOVE!

solarstik.com

SOLAR STIK

Return on Investment

- Run-time Reductions
  - 50-60%
- Fuel Savings
- Maintenance
- ROI Period



Conclusion

- Hybrid System Contributions

- Microgrids Available to Small/Remote Units

Q & A

Contact

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Colonel, US Army-Retired
azaccor@solarstik.com
703.835.0217

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226½ West King St.
St. Augustine, FL 32084
USA
1.800.793.4364 x 109
GSA Schedule Contract # GS-07F-0079V

Polaris Range EXtender Technology (REX)

National Defense Industrial Association

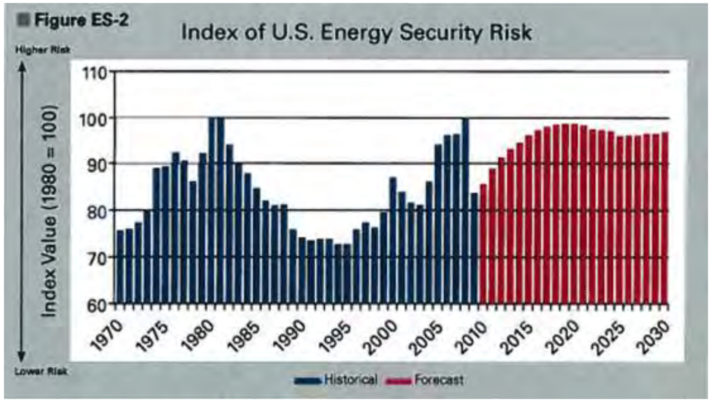
Joint Service Power Expo

Myrtle Beach, SC

May 5th, 2011

The Fuel Efficiency Problem

POLARIS



ESR Index Established - 2008

Afghanistan: "…each gallon of fuel costs 7 gallons to transport"

FOB use of fuel, 2004-2009: 50M to 500M gallons

Fmr CIA Director Woolsey: "getting gas to an M1A1 in Fallujah…costs up to $100 a gallon *or more"*

"70% of the tonnage delivered to deployed forces is fuel" – Rep. Roscoe Bartlett, R, MD-6

Feb 2011 - PM-JLTV: Fully burdened cost of fuel in Afghanistan is $330/gallon

IMPACTS of Saving 1% Fuel

$5-82B
Fewer Dollars Spent on Fuel

6,444
Fewer Soldier Trips

37
Fewer Casualties

GEN Dunwoody, TWV Conference, 2011

The Warfighter's Load Problem

POLARIS

2005-2010

2001-ongoing

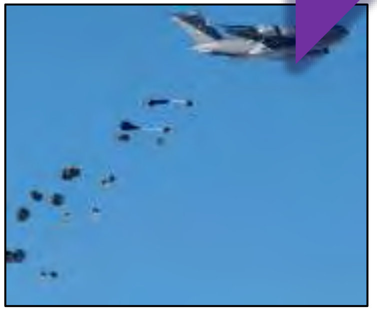
Soldier Weight and Equipment Increases

IEDs force supply lines off roads – aviation used to ship supplies

"Clear and Hold" Strategy moves into more rugged terrain

2007- Iraq;
2009 - Afghanistan






- Combat Load in 1991: 60lbs; Today: 130lbs
- Batteries for a 3 week patrol, Marine Squad: 700lbs
- Doctrine in 1991: Air/Land, Force on Force; Today: Asymmetric, IED-laden LoCs, avoid the heavy vehicles on predictable roads of travel

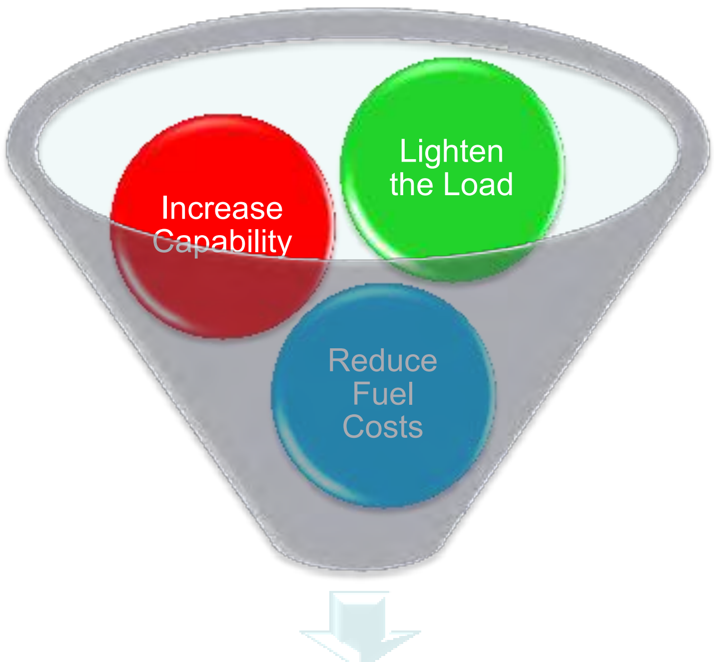
Case Study: Military Use – ATV/UTVs

POLARIS

- ✓ 1992: 1st use of ATVs by the military
- ✓ 2002: TF Dagger requests 1st Militarized ATV
- ✓ 2007: 1st Militarized Side-by-Side Class Vehicle – IDF incorporates into TOE and Doctrine
- ✓ 2009: 1st Militarized strike / recon platform for JSOTF-A
- ✓ 2010: 1st Militarized LSEV
- ➢ 2011: The REX Technology

Convergence of the Problem Sets

- All-terrain, on/off-road, load bearing tactical vehicle
- Quiet, stealth modes
- Longer range (fossil & EV)
- Increased auxiliary power requirements
- Unmanned building block options
- Stand alone, dismounted power generation
- Quick, COTS technology with low fuel costs



Highly mobile, capable and efficient platform

The Polaris REX Technology

Emissions and Fuel economy
Trends in the Automotive Powertrains

- Emissions reduction and fuel economy needs are driving a fundamental shift in Internal Combustion Engine efficiency and power density

- Trend toward reduced emissions, same power from smaller engines

2010
Ford Triton V8
5.4 liter displacement
310 hp
365 Ft lb Torque
14/20 mpg

2011
Ford EcoBoost V6
3.5 liter displacement
365 hp
420 Ft lb Torque
16/22 mpg

Current Technical Paths to Reduce Emissions and Fuel Consumption

- Engine downsizing
  - Reduced displacement and cylinder count
- Turbocharging
  - Increase power density
- Driveline efficiency Increase
  - Reduced parasitic losses for accessories
  - Reduce friction in engine
- Engine start/stop capability
  - Integrated starter/generators
- Driveline electrification
  - Battery powered electric vehicles
  - Parallel and serial hybrids

Limitations on Electric Vehicle Utility

POLARIS

- Vehicle range is limited by battery capacity
- Vehicle utility is limited by recharging time
- Relatively poor power density for batteries
- No widespread recharging infrastructure
- Add-on cost of batteries
- Weight and packaging considerations of batteries
- Range Anxiety presents obstacle to increased adoption of electric vehicles for on-road use

Hybrids are a bridging technology between pure electric and internal combustion powered vehicles

Polaris REX Technology

POLARIS

- Combines advances in powertrain downsizing and efficiency with electric vehicle technology to increase vehicle utility
- Uses existing, proven technology
- Allows for the best combination of vehicle range and emission reduction and fuel efficiency
- Leverages existing fuel infrastructure for electric vehicles with „instant" recharging capability

A Better Bridge

Traditional Parallel Hybrids

POLARIS

- Internal combustion engine is sized to handle transient acceleration loads
- Engine nearly as large as engine in traditional internal combustion powered vehicles
- Due to its size the engine runs in a low efficiency region for much of its operating range
- Engine size compounds vehicle packaging challenges
- Engine size increases vehicle cost

Current Hybrid Solutions Tend to be *ENGINE DOMINANT*

A New Approach

- Create a *battery dominant* hybrid electric vehicle
- Utilize battery for transient acceleration needs
- Size the engine to maintain battery SOC during steady-state driving
  - Incorporate aggressive regenerative braking strategy
- Utilize engine downsizing technology to provide best combination of high power density and small package size for the internal combustion engine
  - Engine maintains battery SOC only
  - Series hybrid

Technology Demonstrator

POLARIS

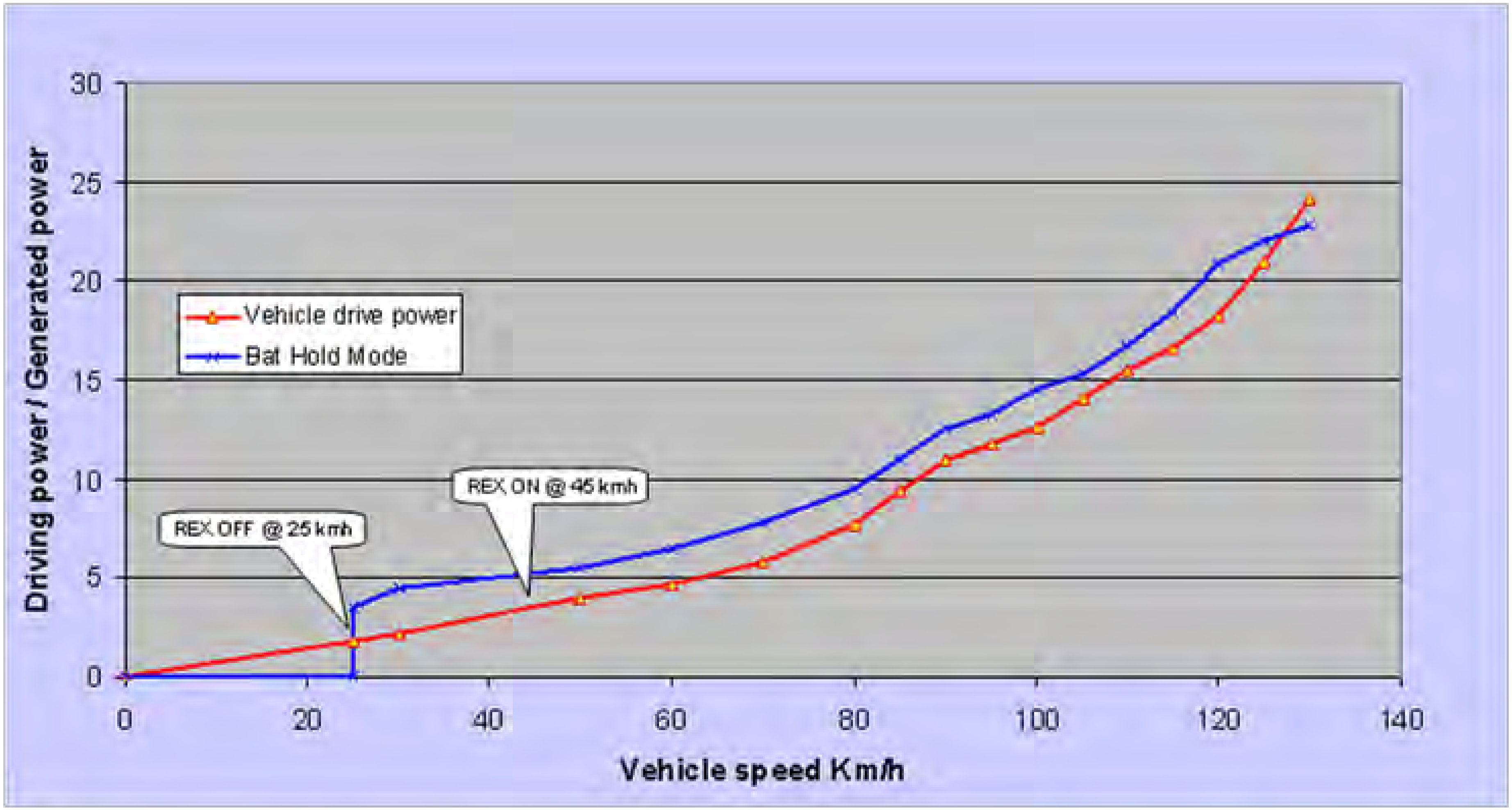
- Polaris REX technology demonstrator based on a European-market VW Polo
  - Up to 500 miles operating range
  - Emissions certification levels lower than a Chevy Volt or Toyota Prius
  - Aerodynamic improvements to reduce „pure losses"
  - Aggressive braking regeneration strategy

Polaris Electric Vehicle REX Strategy

POLARIS

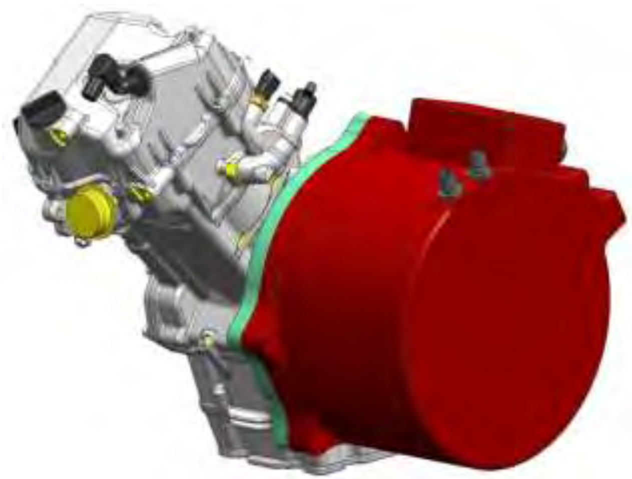
- Powertrain and battery pack is sized for the needs of typical duty cycle
- Transient acceleration needs are met with the battery
  - Partially recovered with regenerative braking
- REX generator sized to slightly exceed average vehicle power needs in typical usage
- No need for remote charging infrastructure
  - The existing gasoline infrastructure is utilized for „instant" battery recharging via an on-board ICE REX recharging system
- On-board REX recharging system is downsized in displacement as much as possible to increase the efficiency, minimize emissions, and maximum fuel economy
- The battery capacity is reduced from that of a pure electric car since the REX system provides increased range.
- Battery capacity is sized to receive the maximum benefit from the „electric only" range for the emissions certification.
- Battery reduction strategy also has the benefit of reducing cost and vehicle weight

Drive Strategy



Polaris Range Extender Package

- Single cylinder
- Integrated generator
- 325cc displacement
- 38 kg weight
- 22kW electrical output
- Port fuel injection
- Low friction design
- Compact space saving design



Polaris REX Engine

INCREASED EFFICIENCY - Nikasil cylinder coating for improved heat transfer and dormant state capability

REDUCED FRICTION - All rotating members mounted on roller bearings

REDUCED WEIGHT - integrated crankshaft drive and mounting system for generator

REDUCED PARASITIC LOSSES - Crankshaft and cam chain distribute oil to cylinder head

REDUCED WEIGHT - Generator acts as flywheel, dynamic balancer, and starter for engine

INCEASED EFFICIENCY - Small 325cc displacement allows engine to run at its lowest consumption range

REDUCED PARASITIC LOSSES - No oil pump

LOWER EMISSIONS – Oil sump preheated by drive motor coolant

Application of REX technology to Off-Road Vehicles

- Technology demonstrator based on Polaris *Ranger EV*
- Utilize Polaris 22kW REX engine and generator
  - Relatively higher power needs due to poor aerodynamics and 4 wheel drive system
  - Drive strategy reconfigured for off-road use
- Results
  - 3X better fuel economy than gas powered Ranger 800
  - Up to 50 mph top speed
  - Reduced battery capacity
  - 10X driving range increase of base Ranger EV

+

+

+

=

Polaris Off-Road Capability + Stationary Power Generation + Fuel Economy + Extended Range = *RANGER™ Hybrid!*

Ranger Hybrid Operating Modes

- Three driving modes
  - Pure electric
    - Approximately 30 mile range depending on duty cycle
    - Reduced IR signature
    - Quiet operation
  - Extended range REX mode with power limit for fuel economy
  - REX mode with power boost for increased acceleration
- Stationary power generation mode
  - Up to 22kW power generation
    - Configurable in 12/24 V DC and 110/220 V AC

Future Developments

- V-twin gas engine for higher power needs
- Heavy fuel engines up to 45 hp
- Apply REX Hybrid concept to higher capability vehicle platforms
  - Ranger Crew
  - RZR 4
- Develop 300V applications for higher efficiency and generation capacity

Conclusion

- Problem Statements are clear!
  - Increase Efficiency
  - Increase Capability
  - Lighten the Load

- REX Offers a Polaris-solution, based on 16 years of work with the US and Worldwide Militaries and Special Forces

- Outside the Box thinking, rapid prototyping, and the use of COTS technology make this possible

Questions?

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Mr. Patrick Weldon
Manager, Business Development
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Optimizing Remote Deployment Energy Systems

Pulse Micro Smart Grid

Bruce Cullen, Pulse Energy

Joint Service Power Expo, Myrtle Beach, SC

May 5, 2011

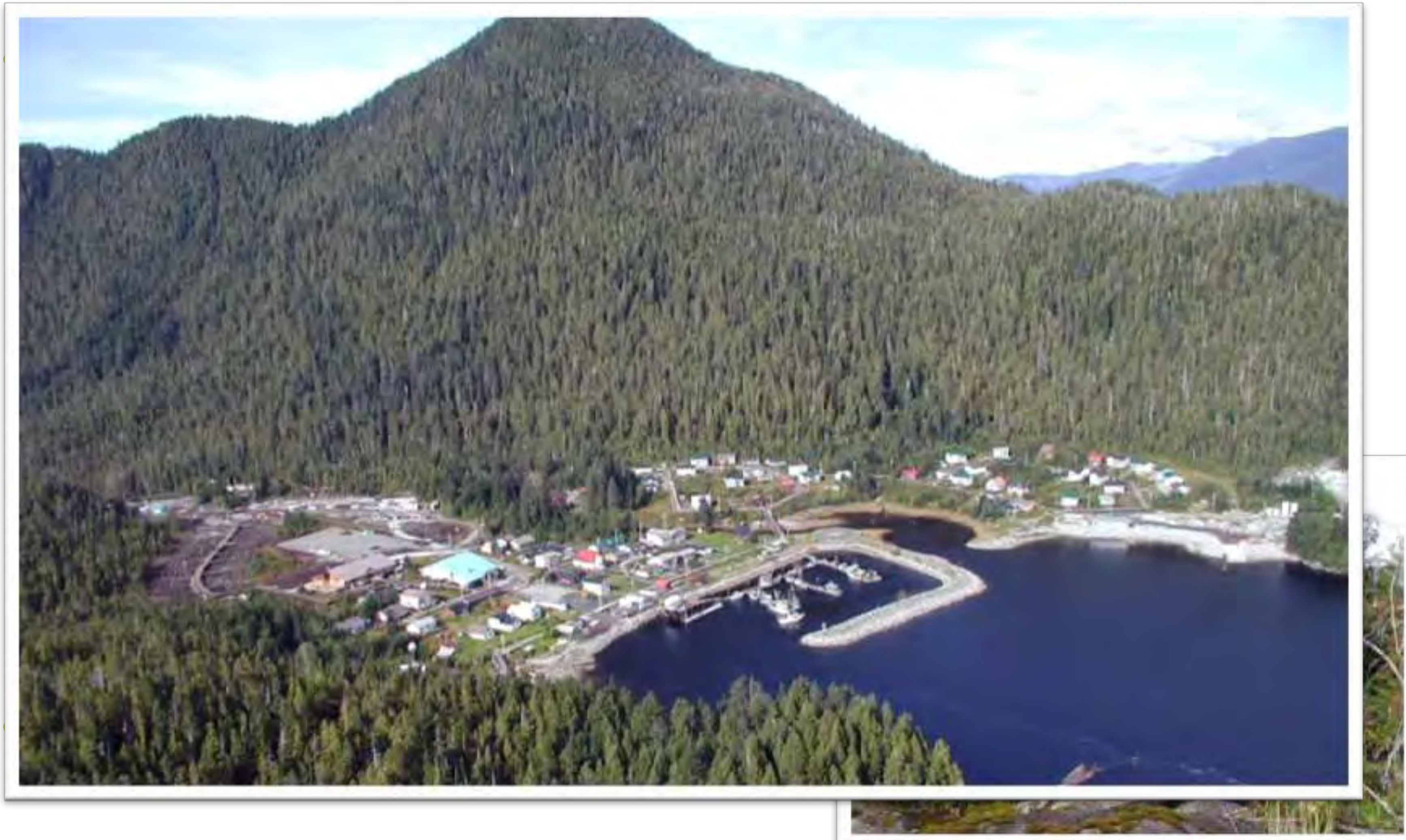
Outline

- Remote Energy Problems
- Canadian Off Grid Test Site
- Demand Management Targets
- Demand, T&D and Supply Side Improvements
- Pulse Micro Smart Grid
- Peak Demand Data Management
- Demand Response
- Remote Energy Solutions

Energy Problems in Remote Locations

1. Fuel trips into remote deployments are hazardous
2. Diesel will continue to be the fuel of ‘need’
3. Fuel costs are very high and unpredictable
4. Buildings do not operate very well
5. Demand data is not used to inform generation

Hartley Bay, BC - Canada's Pacific Coast



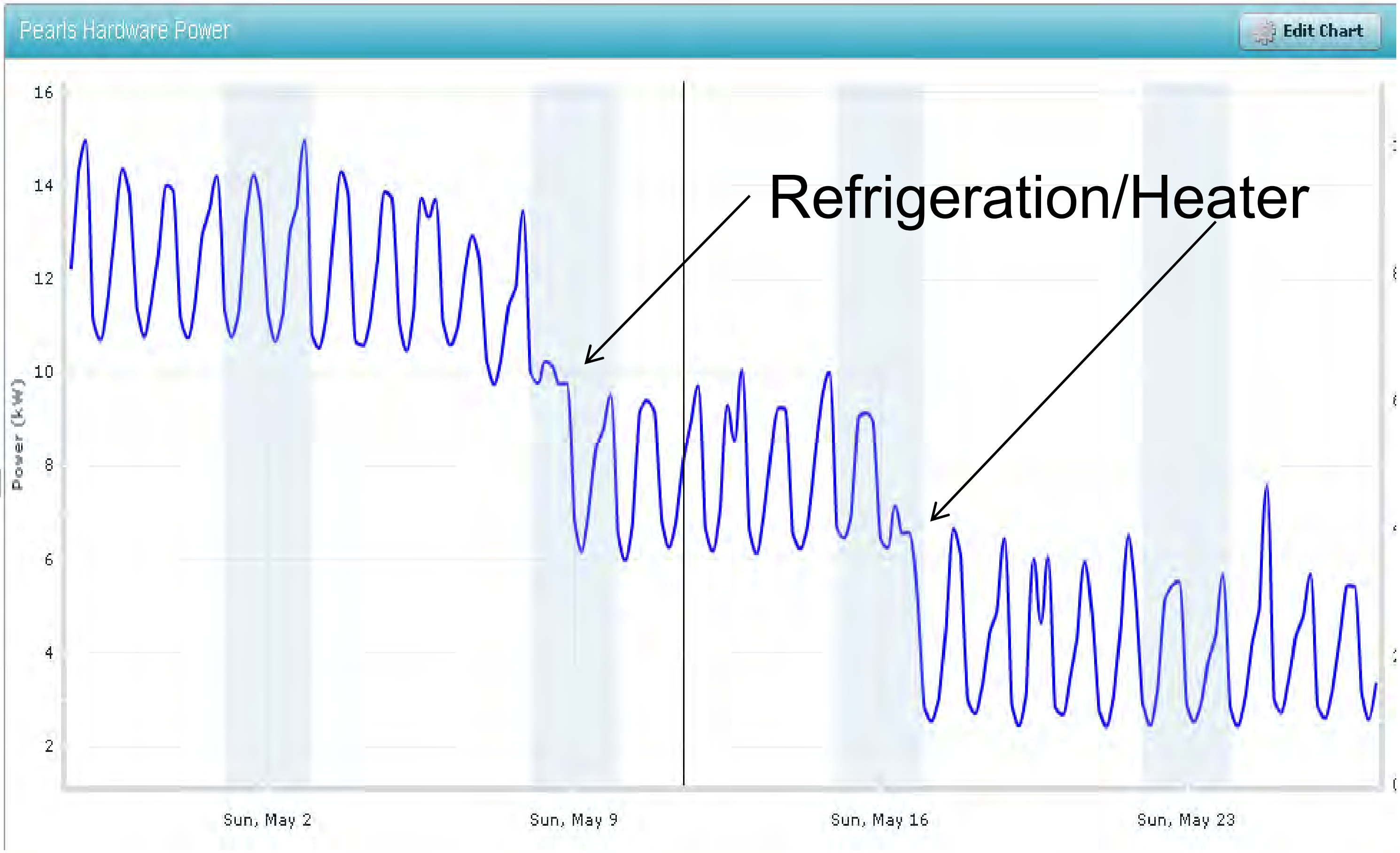
Demand Management Targets

- Smart Meters on every facility and Generator
- Targeted Retrofits
- Energy Anomalies – Email notification
- Peak Load Management, 6000 hours
- Power Quality Issues
- Distribution Losses, Generation Losses
- Pulse Data Analysis for entire micro smart grid - (4 million data records in 18 months)
- *Demand Response*

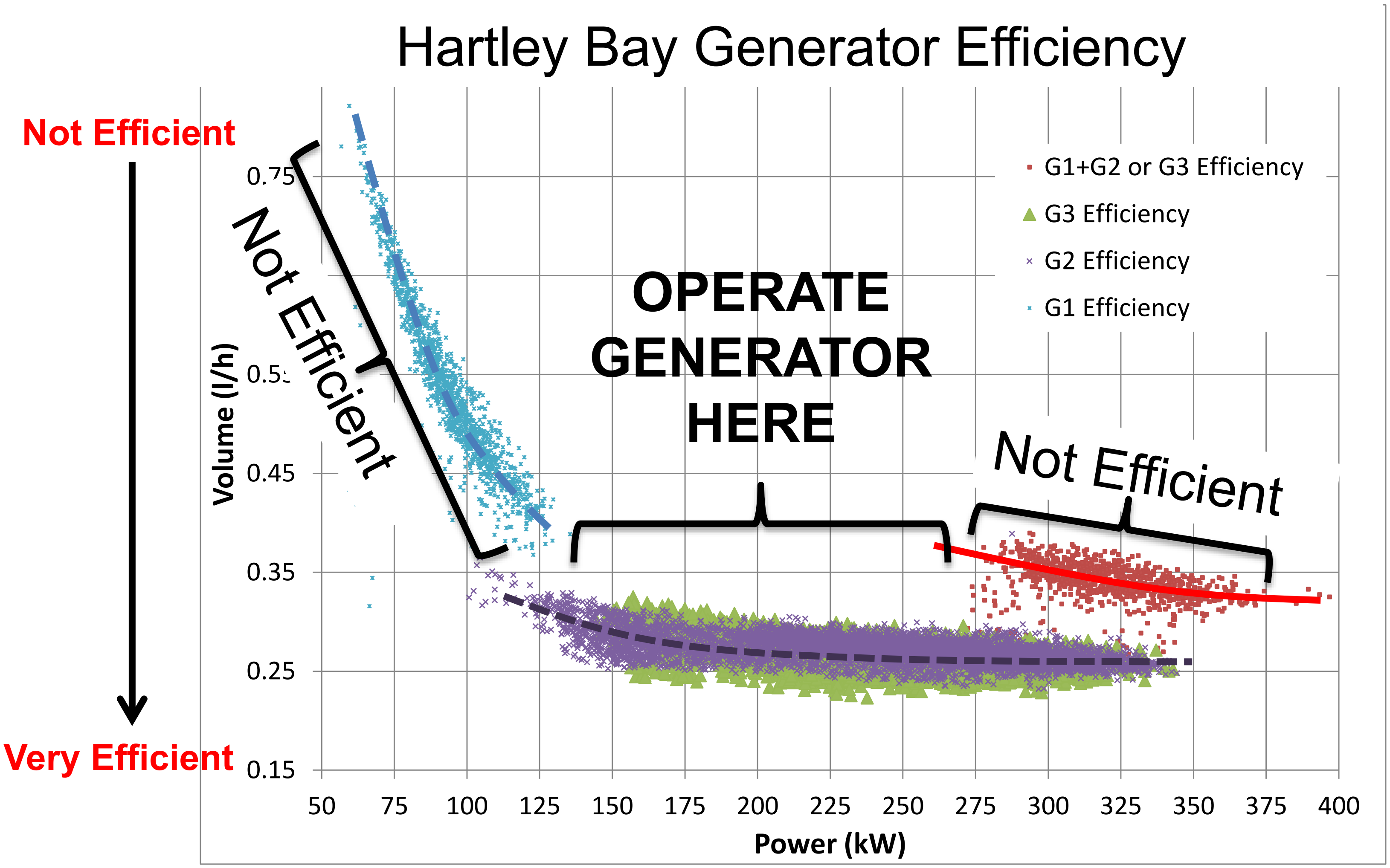
Energy Anomaly Repaired!
$ 35,000 savings per annum

Real Time Energy Management

- Unnecessary Machines left on Waste Energy!

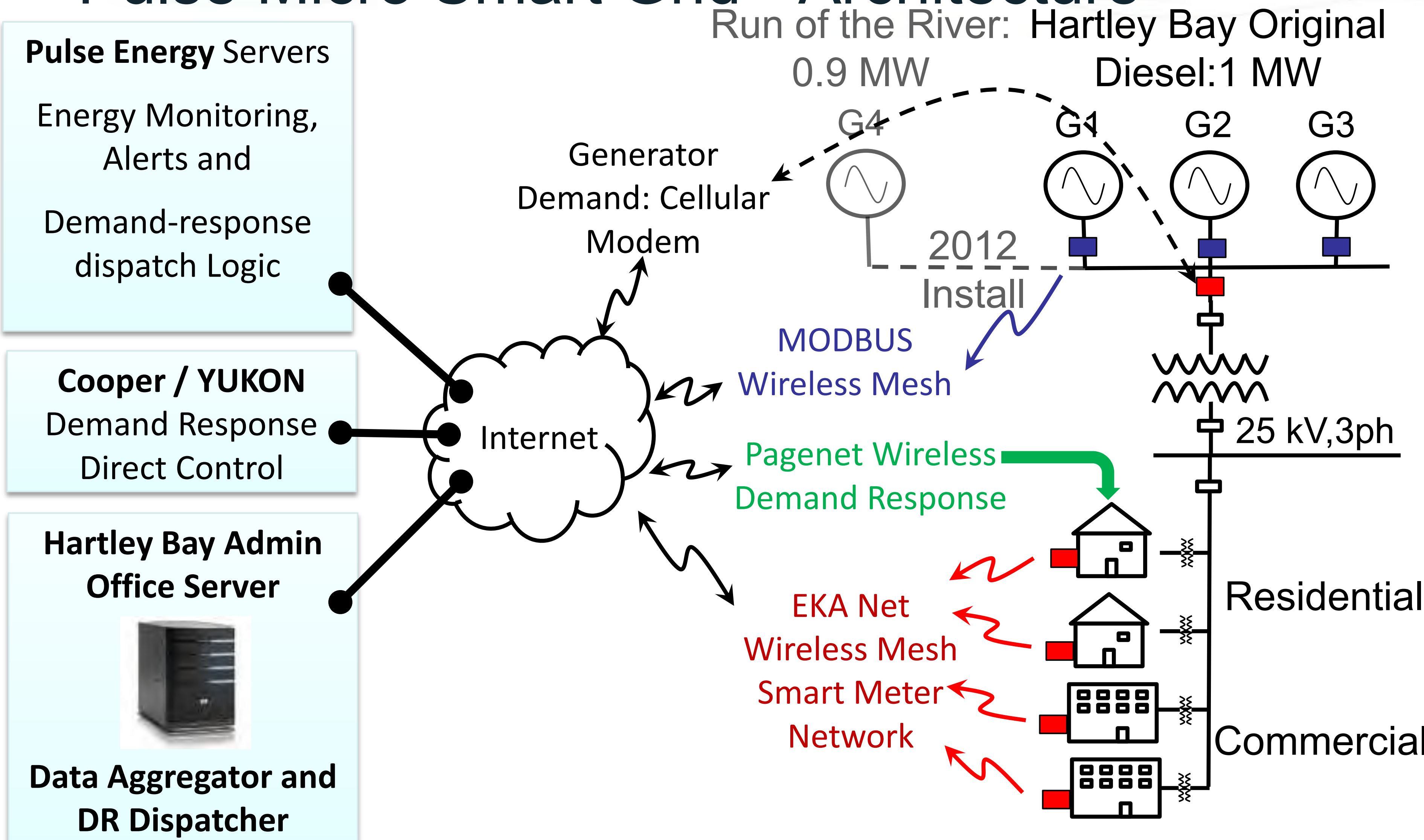


Supply Side Management

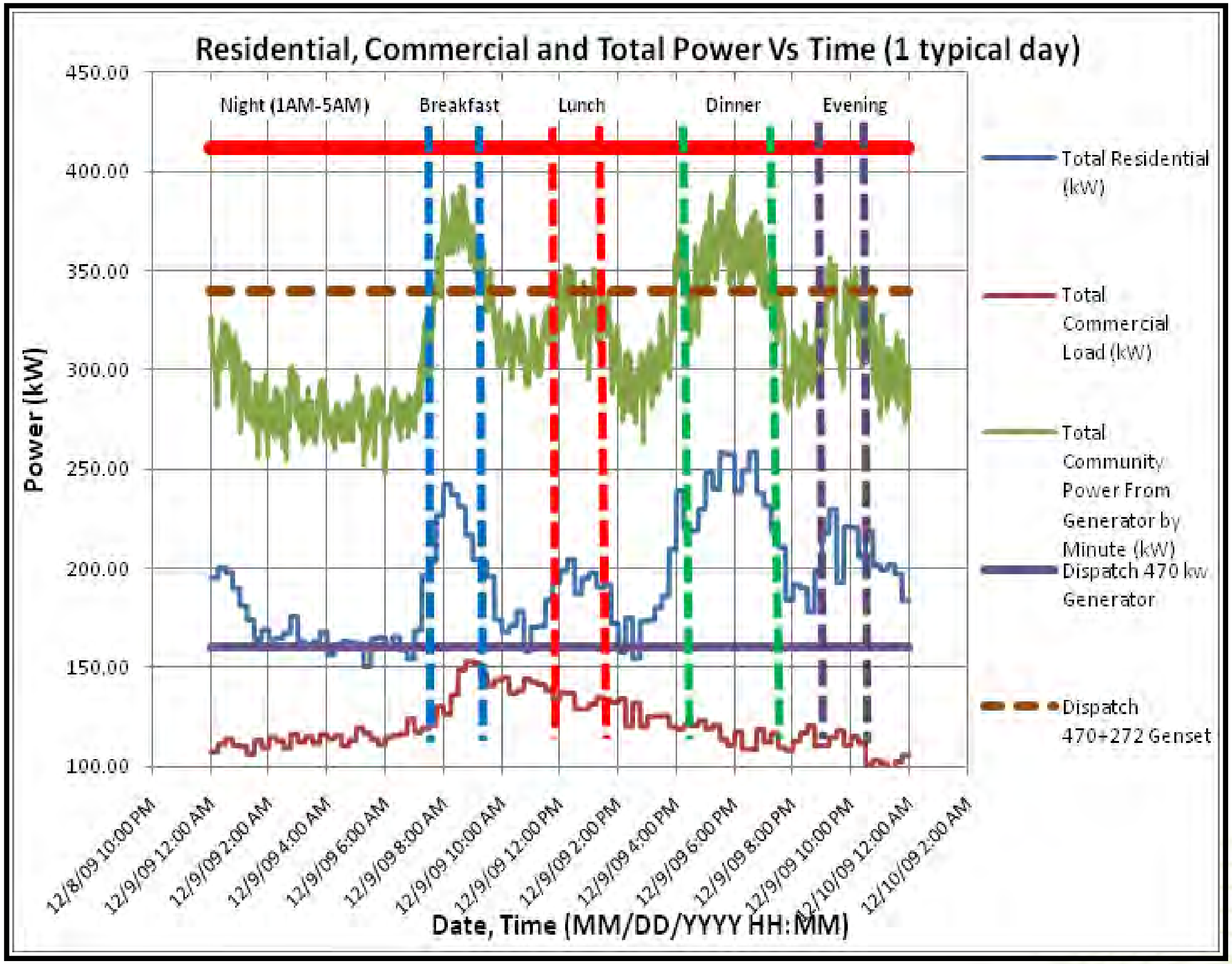


Real Time Asset Management

Pulse Micro Smart Grid - Architecture



View and Analyze Real Time Loads



Demand Response

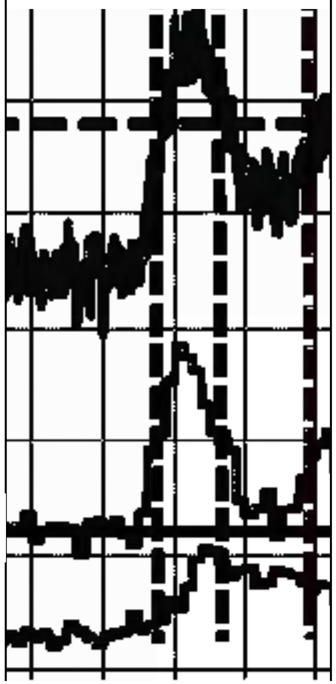
Peak Demand – 20% Peak Load Control

Breakfast

Total >

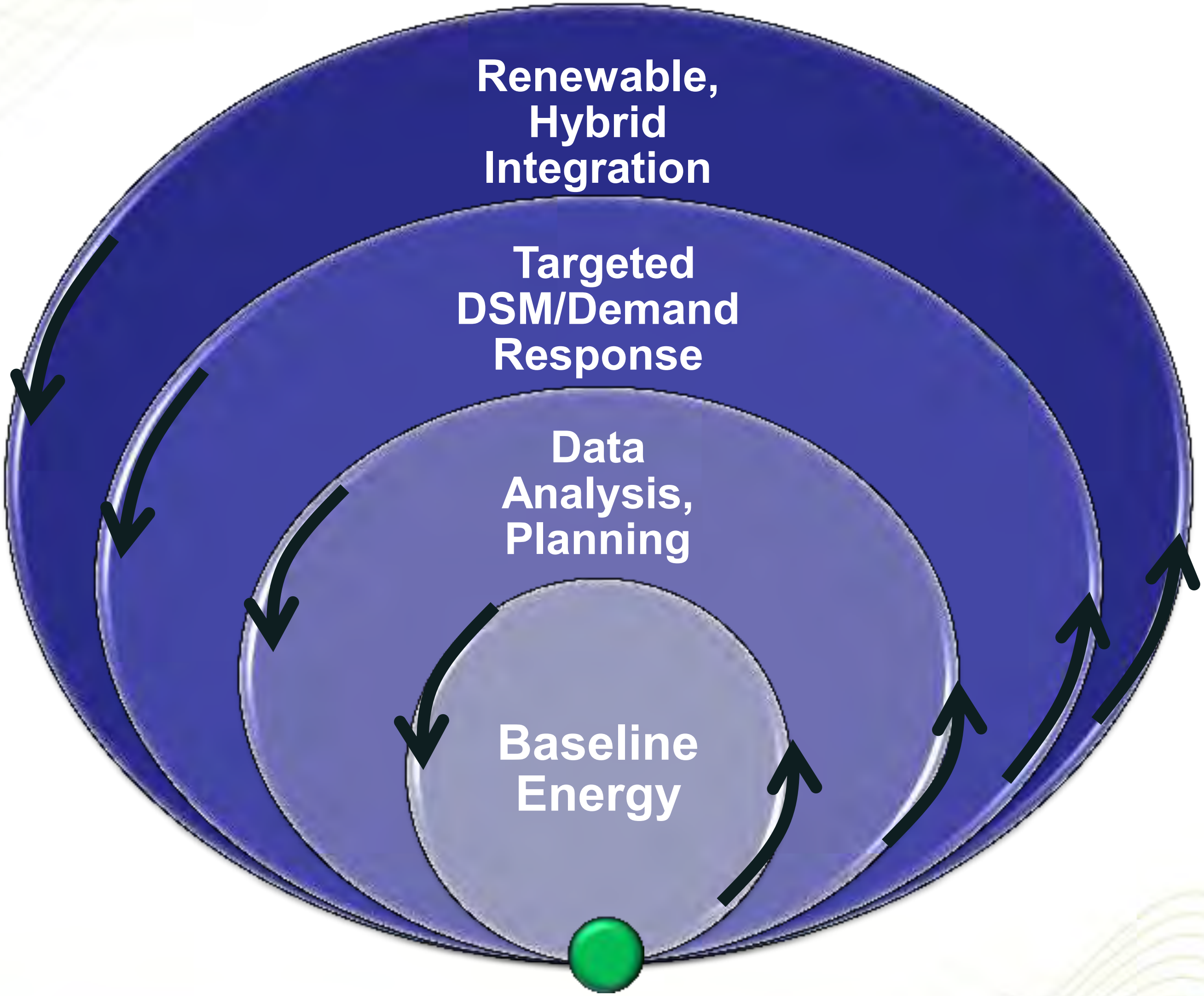
Residential >

Commercial >



Load Control

From Micro Grid to Micro Smart Grid



Pulse Energy Manager

Energy Solutions in Remote Locations

1. Reduce fuel trips by reducing consumption

   20% savings in Pulse Off Grid Pilot!

2. Invest in diesel electric technology solutions

   Don’t wait for a renewable solution!

3. Reduce fuel consumption by knowing not just where but also when power is consumed.
4. Target highest consuming facilities for retrofits, demand response and staff training.

   Take Basic Steps Immediately!

5. Use Facility Demand data to inform Generation.

Optimizing Remote Deployment Energy Systems

Pulse Micro Smart Grid

Bruce Cullen, Pulse Energy

Joint Service Power Expo, Myrtle Beach, SC

May 5, 2011

SENTRY VIEW
SYSTEMS

PROTECTION | SURVEILLANCE | SECURITY | PRESERVATION

Security, Surveillance, Communications & Lighting Solutions

Taking Surveillance & Efficiency To a Whole New Level

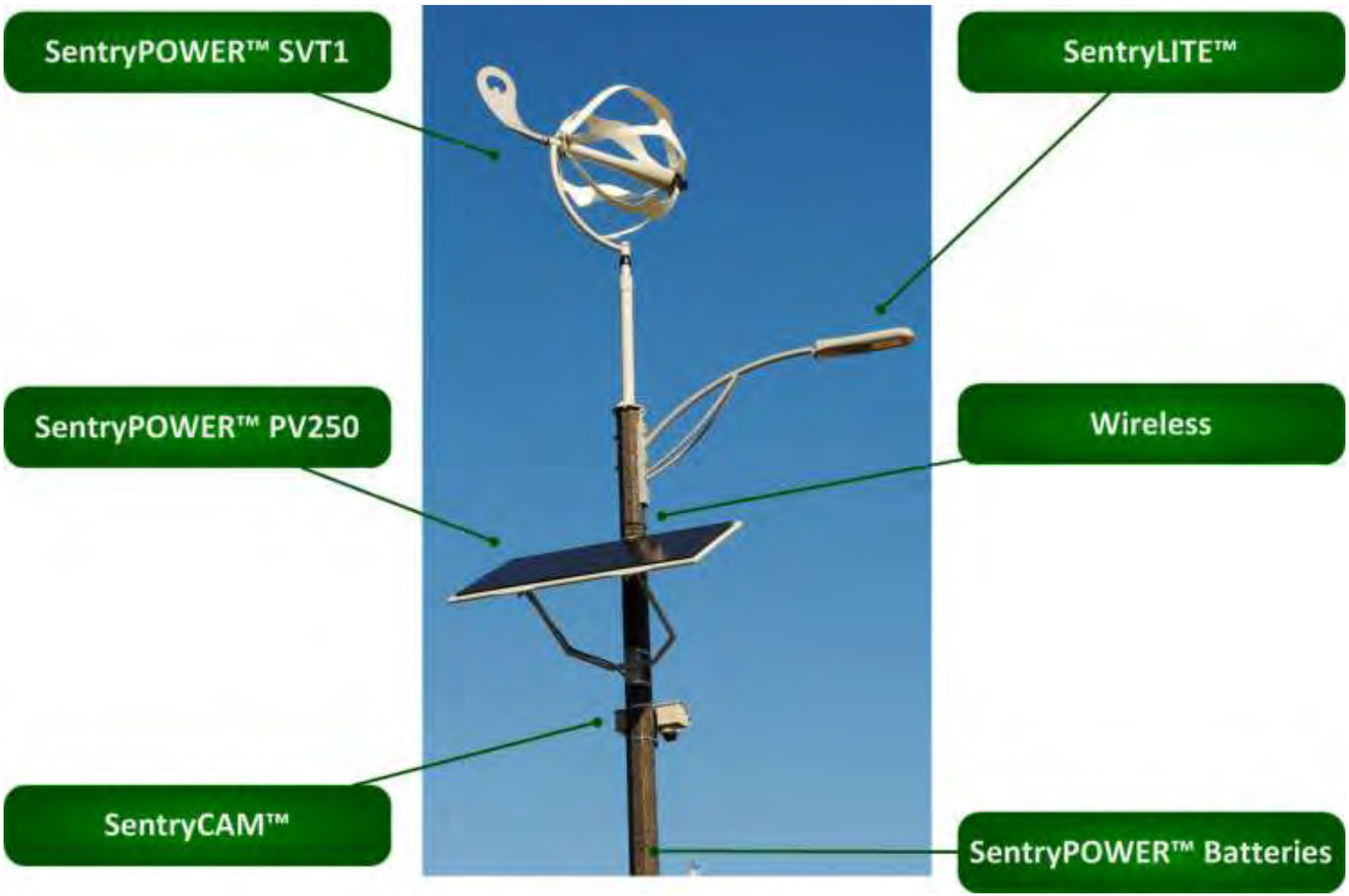
Presentation Agenda

- Remote Surveillance & The SentryPOST™ Solution
- About Us – Sentry View Systems
- Q&A

Remote Surveillance

- Challenges
  - Power
    - Costly infrastructure installation
    - High generator fuel cost – approaching $100/gal for the remotest of locations
  - Communications
    - Long distances
    - Difficult & expensive cable installation costs
  - Environmental permitting
- The Solution…SentryPOST™

SentryPOST™ Solution



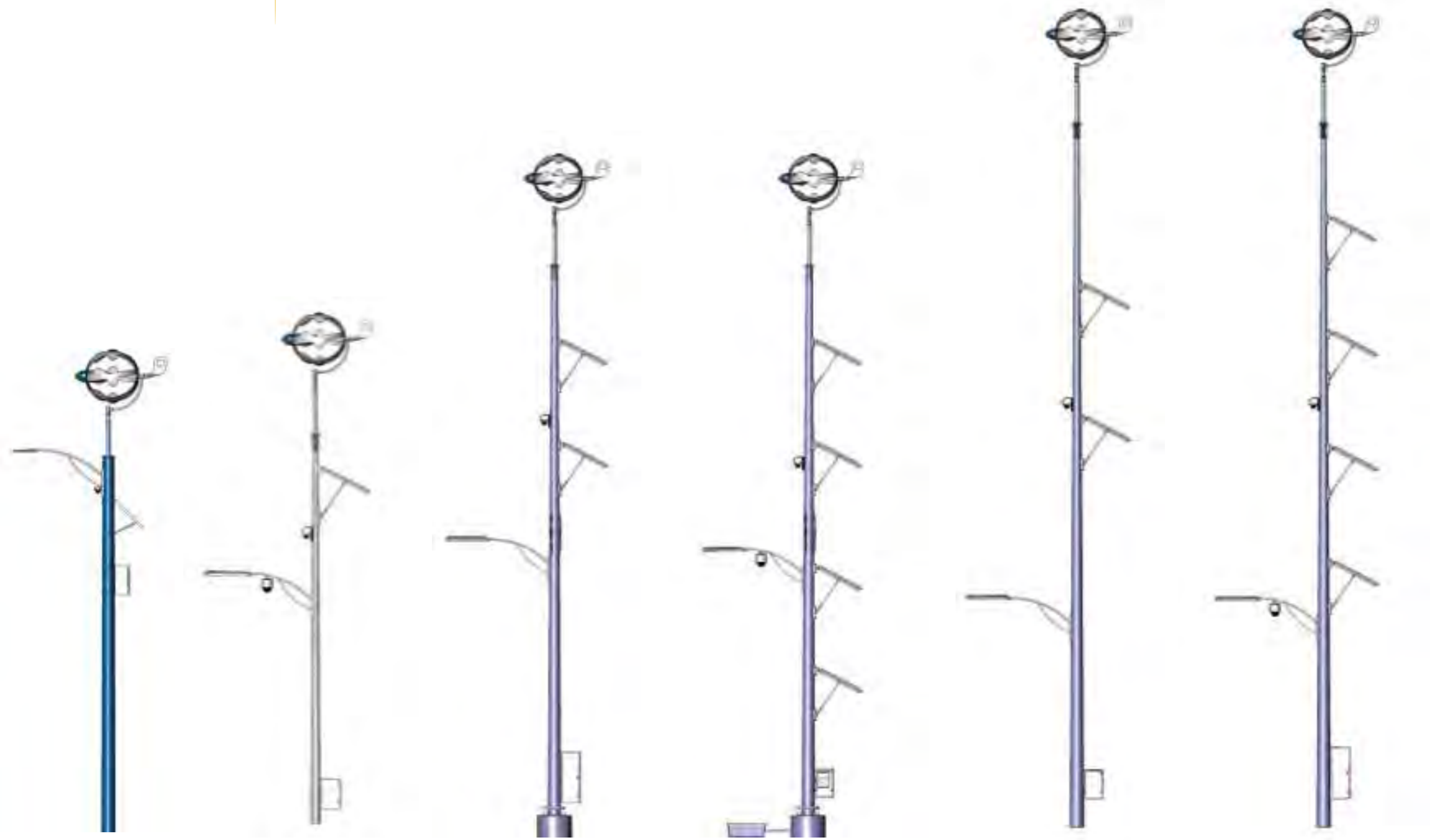
SentryPOST™ Configurations

- Municipal, Decorative Pole
  - Variety of style options possible
  - Partnered with multiple pole manufacturers to provide the right pole for your need
  - Aluminum, Steel, Composite

SentryPOST™ Configurations

- Industrial Applications
  - Rugged and durable poles & hardware
  - High mast pre-stressed concrete options
  - Thick wall steel, tilt-down pole options
- Mobile Applications
  - Light duty trailer / truck bed module
  - Heavy duty trailer module

SentryPOST™ Configurations



SentryPOST™ Configurations

Standard Pole Offering

- 30ft height (excluding SVT1)
- Thick wall steel construction
- Tilt-down design for easy access to elevated appliances with no man-lift

SentryPOST™ Configurations

Prototype

Will be unveiled at FPED

Concept

Design details subject to change

SentryPOST™ Configurations

SentryPOWER™

- SentryPOWER PV250
  - 250 Watt PV panel (other sizes available)
  - Nearly 18% cell efficiency
  - 5 year product warranty
  - 25 year product life expectancy
  - 90% output after 10 years
  - 80% output after 25 years

SentryPOWER™

- SentryPOWER PV250
- SentryPOWER SVT1
  - Spherical Venturi Turbine
  - 1.1 meter diameter turbine
  - 6 blade turbine – maximizes gain
  - 500 Watt unique, high efficiency design
  - 4.5 mph cut-in wind speed

SentryPOWER™

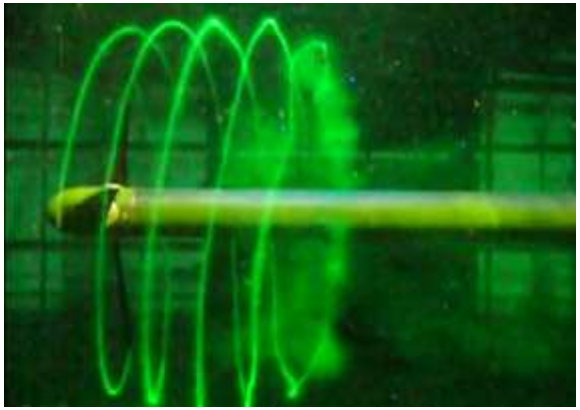
- SentryPOWER PV250
- SentryPOWER SVT1
- SentryPOWER SVT2
  - 2.2 meter diameter turbine
  - 7 mph cut-in wind speed
  - 2.2 kW generator

SentryPOWER™

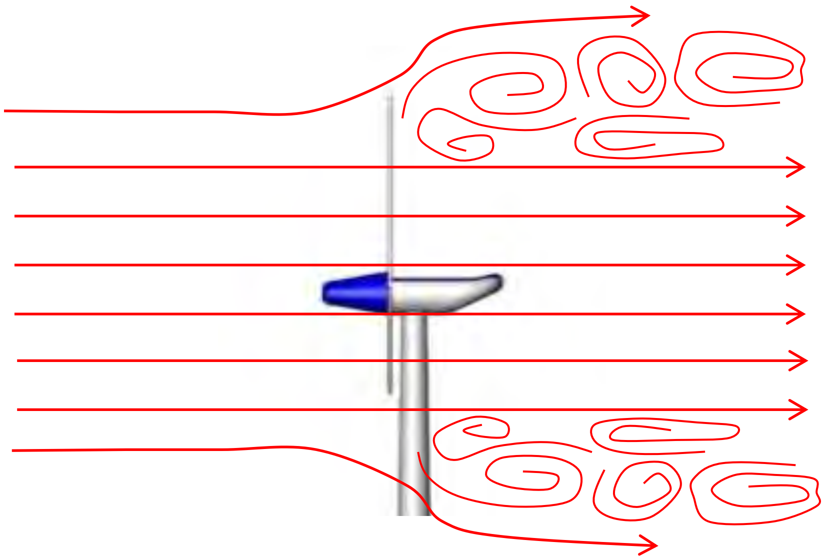
- SentryPOWER PV250
- SentryPOWER SVT1
- SentryPOWER SVT2
- SentryPOWER MTU (Mobile Tactical Unit)
  - Tripod mounted SentryPOWER SVT1
  - Photovoltaic tent
  - 400 Amp·Hr battery & charge controllers
  - Rugged transport cases for mobility

Spherical Venturi Turbine

- Wing Tip Turbulence
  - Vortices generated by blade wingtips create drag
  - Decreases turbine efficiency

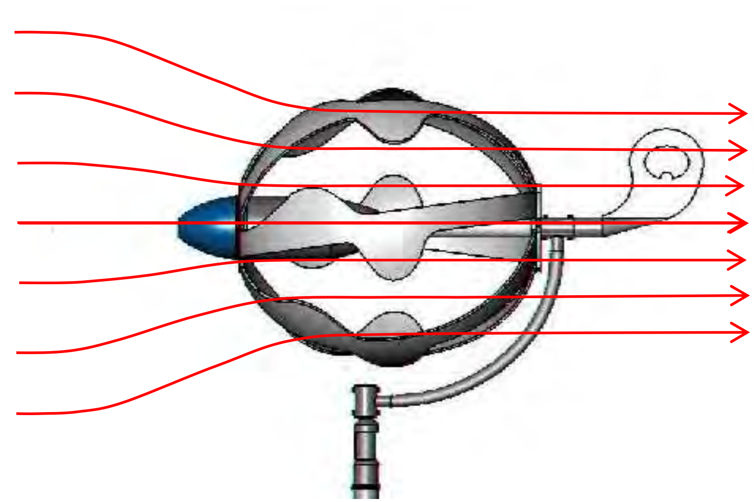


Spherical Venturi Turbine



<u>Traditional Prop</u>

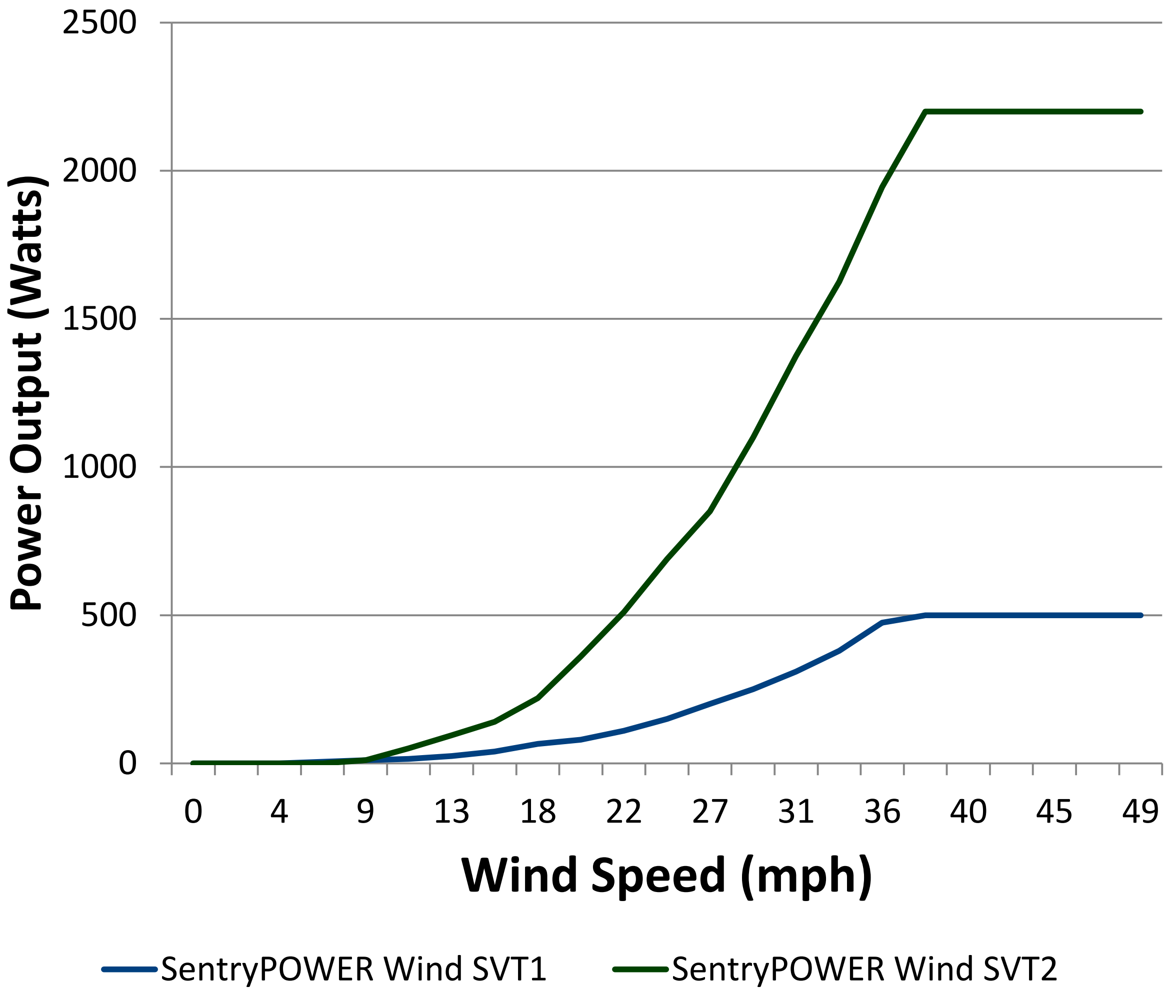
Virtual / Effective diameter is smaller than physical diameter



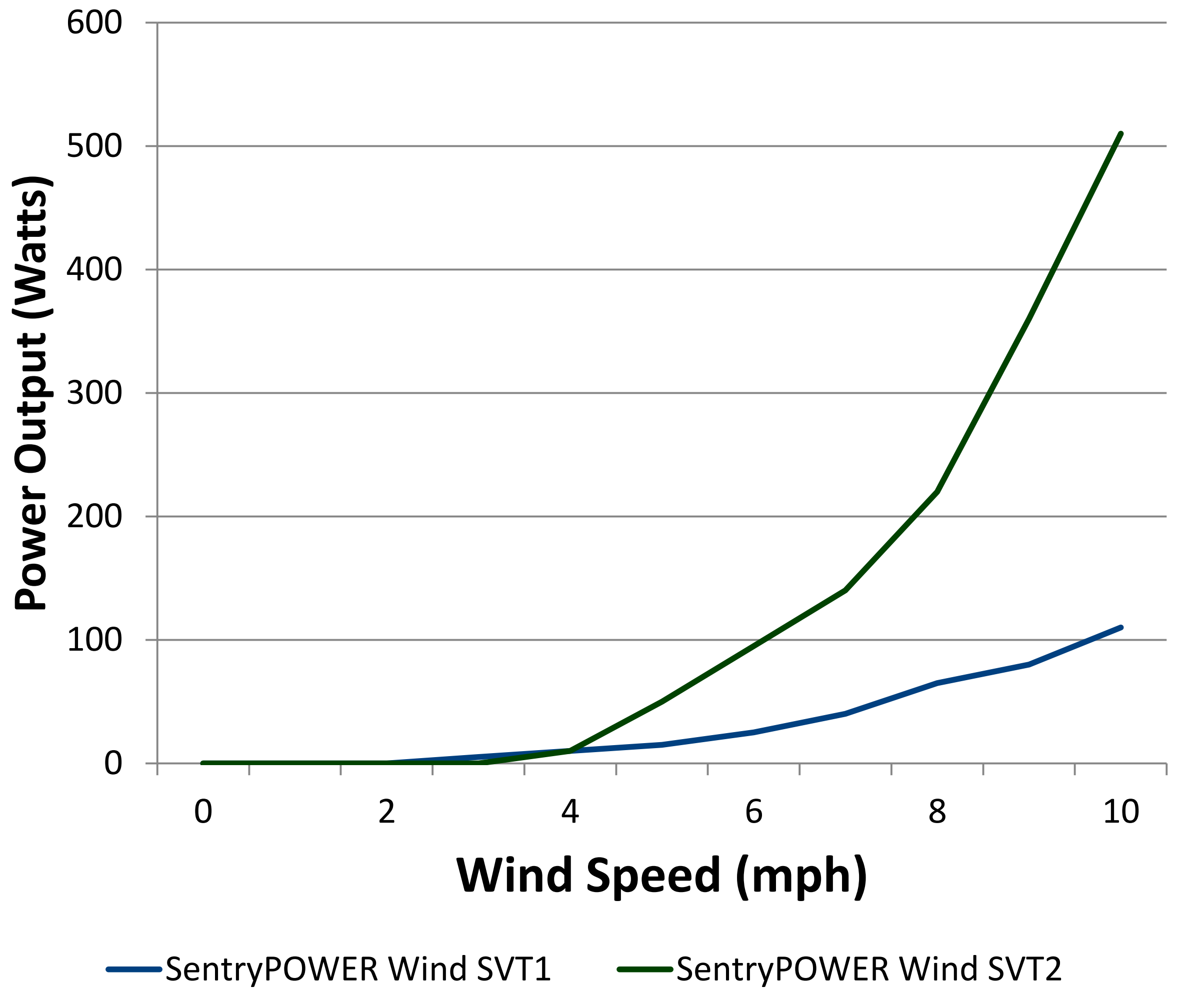
<u>Spherical Venturi Turbine</u>

Virtual / Effective diameter is larger than physical diameter

SentryPOWER SVT Output



SentryPOWER SVT Output



SentryNET Commander™

- Supervisory Control And Data Acquisition (SCADA)
- Intelligent edge device monitoring & control
- Programmable power relays
- Contact closure inputs
- Temperature & humidity monitoring
- Latching alarms with programmable states
- Less then 1 Watt power consumption
- Configuration Software for Windows or Linux included on USB drive or CD
- Operating temperature -40° to +60°C

SentryNET Commander Pro™

- SCADA & temperature monitoring
- 10/100 network interface
- Web interface for configuration (no external software required)
- On-board data logging (SD card)
- LCD readout
- Real time clock (battery)
- Programmable power relays
- Analog inputs & contact closure inputs
- Latching alarms with programmable states
- Operating temp -40° to +60°C

SentryNET Commander Power Pro™

- All the features of Pro configuration
- Analog inputs
- Dual input AGM battery charge controlling (12vdc or 24vdc)
  - SentryPOWER PV input (solar)
  - SentryPOWER SVT input (wind)
- LVD protection from battery deep discharge
- Operating temp -40° to +60°C

SentryNET Commander Power Pro Plus™

- All the features of Power Pro configuration
- Triple input AGM battery charge controlling (12vdc or 24vdc)
  - SentryPOWER PV input (solar)
  - SentryPOWER SVT input (wind)
  - Grid or generator 120-240vac input
- LVD protection from battery deep discharge
- Operating temp -40° to +60°C

SENTRY VIEW SYSTEMS

SentryLITE™

- Long Life LED roadway luminaire
  - 50 Watt 120-240vac / 4350 lumen
  - 50 Watt 24vdc / 4350 lumen
  - 100 Watt 120-240vac / 5900 lumen
  - 150 Watt 120-240vac / 11800 lumen
- Dark Sky Compliant
- Drop in replacement for existing HID roadway lighting
- 60,000 hr. rated life (6.8 years)

SentryLITE™

- Optional Integrated SentryCAM™
  - Fixed mini-dome on SentryLITE™ housing
  - PTZ dome on light mount

SENTRY VIEW SYSTEMS

Communications

- Wireless
  - Wi-Fi, Wi-Max, Mesh
  - Point-to-point, point-to-multipoint
  - 4G, microwave
- SATCOM
- Optical Fiber
- LAN

Value-Added Integrations

- Imagers
  - SentryCAM™
  - Thermal
  - NIR Illuminated

Value-Added Integrations

- Imagers
- Video Storage
  - SentryNET EdgeDVR™
  - SentryNET Central NVR™

Value-Added Integrations

- Imagers
- Video Storage
- SentryNET SightCommander™
  - Video Management System
  - Situational Awareness Enhancement
  - Custom Application Development

Value-Added Integrations

- Imagers
- Video Storage
- SentryNET SightCommander™
- Intrusion Detection
  - Buried Fiber Sensor
  - Laser Trip Wire
  - FMCW & Doppler ground based radar

Value-Added Integrations

- Imagers
- Video Storage
- SentryNET SightCommander™
- Intrusion Detection
- Hostile Fire Detection
  - Optical sensor for rapid detection and heading awareness
  - Weapons identification capability

SENTRY VIEW

SYSTEMS

PROTECTION | SURVEILLANCE | SECURITY | PRESERVATION

Security, Surveillance, Communications & Lighting Solutions

About Us

About Us

- Established in 2000
- Secure, Remote Communications
  - 10 year contract for secure DoD wireless communications platform
  - Teleport in Baghdad
  - Developed SATCOM network in Kosovo
  - Developed NATO SATCOM stations in Angola

About Us

- Deployed Remote Surveillance
  - SentryNODE™
    - 450 installations at high priority DoD sites
    - Commendation received for 100% on time deliveries
    - Current backlog for >150 units

About Us

- Deployed Remote Surveillance
  - SentryNODE™
  - SentryNET Commander™
    - Over 150 units deployed
    - DoD and border surveillance applications

About Us

- Deployed Remote Surveillance
  - SentryNODE™
  - SentryNET Commander™
  - SightCommander™
    - More than 50 DoD deployments

About Us

- Deployed Remote Surveillance
  - SentryNODE™
  - SentryNET Commander™
  - SightCommander™
  - SentryPOWER™
    - Deployed on US/Mexico border
    - 100s of international deployments

About Us

Sentry View Holdings

- Sentry View Systems
  - Remote Solutions
  - Surveillance Solutions
  - Network Solutions
  - Custom Engineered Solutions
- SuperTel Network
  - Program Management
  - Government Contract Management (DOD, DHS, CBP,…)
  - Custom Systems Engineering
- Veri-Core
  - Court Room A/V Recording Solutions

Our Mission

- Protection
- Surveillance
- Security
- Preservation

Our Values

Integrity: the hallmark of our character

Pyramid of Value

CUSTOM ENGINEERED SOLUTIONS

Solutions Summary

Remote

- SentryPOST™
- SentryPOWER™
- SentryNODE™

Surveillance

- SentryCAM™
- SentryVCA™
- Physical Security & Intrusion Detection
- SightCommander™ - custom VMS

Network

- SentryNET Commander™
- SentryNET™ Suite
- SentryNET EdgeDVR™
- SentrySECURE™

Custom Engineered

- Custom System Engineering
- Custom Product
- Software App Development
- Rapid Prototyping

Solutions Summary

Remote

Surveillance

Network

Custom Engineered

Remote Solutions

- State of the Art Remote Power Systems
- Secure Remote Communications
- The Capstone of Effectiveness

Surveillance Solutions

- Quality Imaging with High Value, Intelligent Analytics
- Customizable Ergonomic Human Interface
- Force Multiplying Remote Assessment Tools

Network Solutions

- Leading Network Capability
- Proprietary, Intelligent Edge Device Monitoring
- Building Blocks For Intelligent Systems

Custom Engineered Solutions

- Agile, Adaptable, Capable
- Rapid Prototyping
- Our Foundational Core Competency

Contact Us

Sentry View Systems

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Comprehensive Integration and Interaction of Equipment Used For Remote Site Systems

Doug Combs BERG Companies

Berg Jiffy Tent

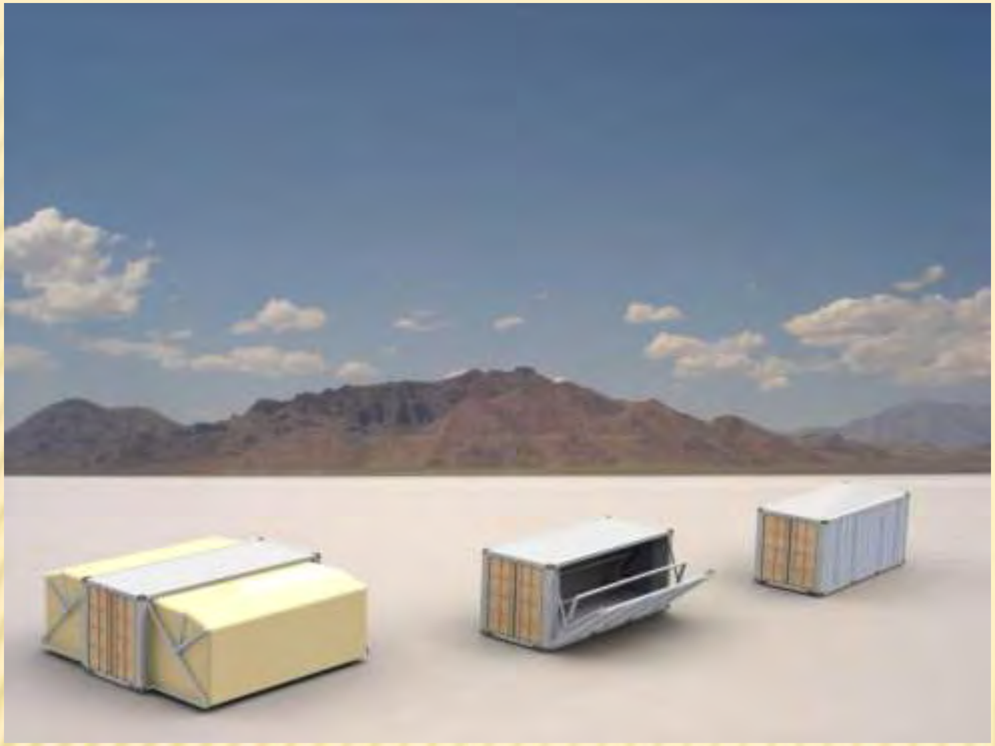
GP Medium

MGPTS


2004 1 28

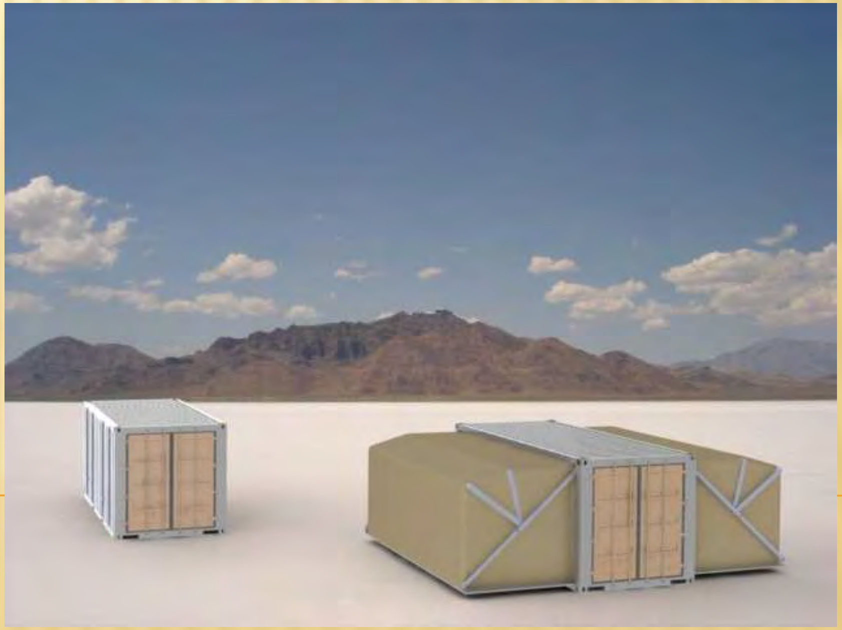


EXIT

Addition of expandable shelters maximizing square foot

- 2 in 1 shelters
- 3 in 1 shelters
- 4 in 1 shelters
- 5 in 1 shelters





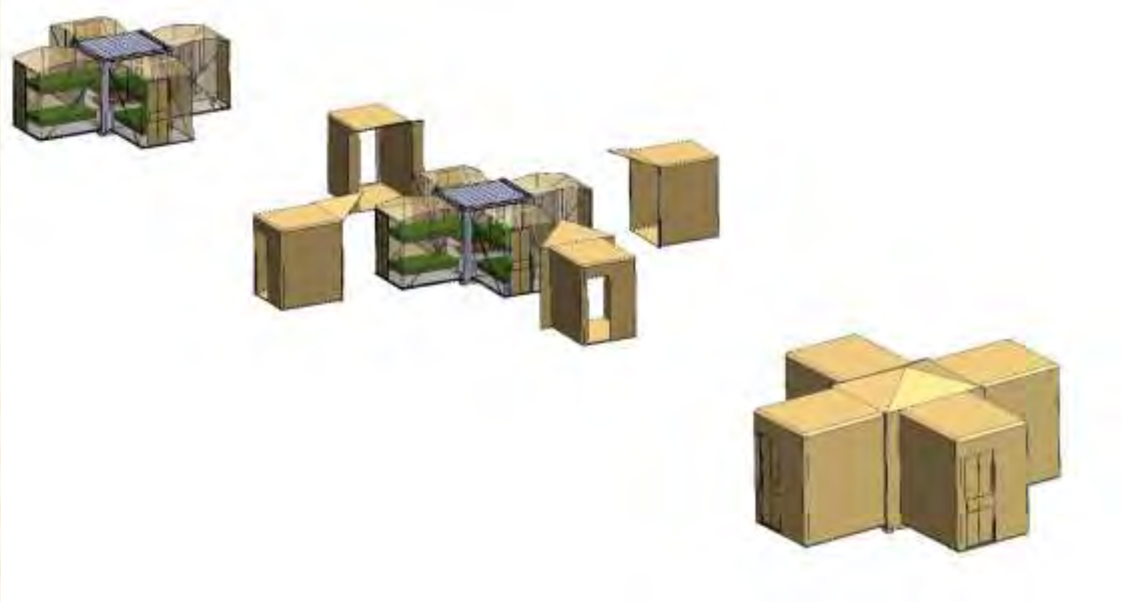

<u>Right size Equipment</u>

- Generators
- ECU's
- Appliances

Increased efficiency in lighting

•LED

•Efficient florescent



Most current and efficient insulation systems
- Reflective insulation double bubble
- Aero Gel fabric composites
- Composite insulation fabrics




Reduce the packed configuration of camps to minimize fuel consumption for deployment without compromising mission capability

Utilization of stronger and lighter weight building materials

- Composite Panels
- Specially designed extrusions
- High profile polycarbonate molded parts

Incorporation of solar collecting and power generating devices